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ABSTRACT

A series of papers will be written to review in a comprehensive fashion the literature related to 3 categories of variables in concept learning: task variables, stimulus variables, and learner variables. This paper, the first of the series, focuses on task variables. Research dealing with instructions, temporal factors, and feedback is critically reviewed and synthesized. Variables related to each of these factors are identified and generalizations are drawn concerning their effects. Results indicated that (1) it was apparent that verbal instructions given the subject prior to concept learning may have had powerful effects on acquisition; (2) the length of time allotted each aspect of concept presentation was shown to affect learning; and (3) feedback, accurate and complete, was most important after an incorrect response. Implications of these generalizations for a model of cognitive operations and for educational practice are also presented. (Author/TA)

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THEORETICAL PAPER NO. 28

VARIABLES IN CONCEPT LEARNING: TASK VARIABLES

REPORT FROM THE PROJECT ON VARIABLES AND PROCESSES IN COGNITIVE LEARNING

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Theoretical Paper No. 28

VARIABLES IN CONCEPT LEARNING: TASK VARIABLES

by
Dorothy A. Frayer
and
Herbert J. Klausmeier

Report from the Project on
Variables and Processes in Cognitive Learning

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Theoretical Paper is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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Abstract

A series of papers will be written to review in a comprehensive fashion the literature related to three categories of variables in concept learning: task variables, stimulus variables, and learner variables. This paper, the first of the series, focuses on task variables. Research dealing with instructions, temporal factors, and feedback is critically reviewed and synthesized. Variables related to each of these factors are identified and generalizations are drawn concerning their effects. Implications of these generalizations for a model of cognitive operations and for educational practice are also presented.

I
Introduction

A vast body of literature on concept learning has accumulated in recent years. At the Wisconsin Research and Development Center for Cognitive Learning (WRDCCL), journals are systematically searched for articles relevant to concept learning. These articles are listed in an annual bibliography published by the WRDCCL for use by scholars (Klausmeier, Robinson, Frayer, & DeVault, 1970; Klausmeier, Sterrett, Frayer, Lewis, Lee, & Bavry, 1969; Klausmeier, Sterrett, Robinson, Frayer, & Bavry, 1969). Since 1950, over 1400 articles dealing with research and theory in concept learning have appeared.

Information from this literature is used by Center staff in planning their own research and development activities. To translate this information into a form which can be effectively used in planning, a series of three papers will be written to integrate and critically review the results of past experimentation. The intent of this series is to review in a comprehensive fashion the literature related to three categories of variables in concept learning: task variables, stimulus variables, and learner variables. Each paper will deal with one of these categories.

The organization of research findings into these categories, though arbitrary, provides a convenient framework for reviewing most of the concept learning literature. To provide the reader with a perspective concerning this framework, a brief description of each category follows:

> Task variables are those related to general characteristics of the learning task rather than to characteristics of the stimuli or the way in which they are presented. Variables in this category include instructions, temporal factors, and feedback.
>
> Stimulus variables deal with the characteristics of the stimuli, methods of presentation, and sequencing. Variables placed in this category include selection vs. reception paradigm, simultaneous vs. successive presentation, number of concept instances, ratio of positive to negative instances, sequence of examples, and type of information (definitions, synonyms, sentence contexts).
>
> Learner variables encompass cognitive, affective, and physical characteristics of the learner. Classified in this category are variables such as intelligence, cognitive style, cognitive abilities, motivation, anxiety, age, and sex.

The present paper will focus on "task variables." Specifically, research dealing with instructions, temporal factors, and feedback will be critically reviewed and synthesized. Within each of these areas, variables will be identified and defined as precisely as possible. When more than one study has dealt with a particular variable, generalizations will be drawn concerning its effect. In the case of conflicting results, an attempt will be made to account for the discrepancy on the basis of methodology.

In selecting articles for inclusion in this review, the intent was to be comprehensive rather than selective. Thus, the scope of the review is broader than any previous synthesis. Kendler (1961), Bourne (1966), Byers (1967), and Sax (1969) have reviewed portions of concept literature. Their articles, together with the present paper, provide a basis for planning research which has high potential for clarifying cognitive operations and suggesting effective instructional techniques.

II
Instructions

Verbal directions are usually given to subjects in concept learning experiments to guide their behavior in performing the task. For the most part, these directions have been written on an intuitive basis and their effects have not been examined systematically. Different instructions, however, have frequently led to significantly different rates of concept learning (e.g., Byers, Davidson, & Rohwer, 1968; Kalish, 1966; Klausmeier & Meinke, 1968; Lynch, 1966; Pishkin, 1965). These experiments suggest that instructions may play a critical role in concept learning.

To clarify the effect of instructions, the dimensions on which they may vary should be specified. The most comprehensive conceptualization of the nature of instructions has been offered by Klausmeier and Meinke (1968). They pointed out that instructions may vary according to purpose, method of presentation, amount of information presented, specificity of information presented, and amount of nonverbal guidance.

Six purposes of instructions were identified: (a) to acquaint the subject with the stimulus material, (b) to acquaint the subject with the response desired, (c) to inform the subject of a strategy or method to apply to solution of the task, (d) to provide substantive information to facilitate concept learning, (e) to provide a set to recall relevant information, and (f) to change the level of motivation of the subject.

Instructions may be presented in audio, visual, or audiovisual modes. The amount and specificity of information contained in instructions and the amount of nonverbal guidance are relative dimensions and must be compared in the context of a specific experiment.

To systematize the current knowledge of the effects of instructions, research results will be organized according to the purpose of the instructions.

Instructions Concerning Stimulus Material

Instructions which explicitly indicate the dimensions on which concept instances vary may facilitate learning. Marks and Ramond (1951) compared performance on a card-sorting task for subjects given instructions which established a "real-life" or a "textbook" situation. Subjects in the "real-life" group were directed to sort cards into exclusive and consistent categories. Subjects in the "textbook" group were given the identical directions with two additions: (a) instructions which indicated that the task was one of helping a fictitious person, "Bill Smith," who had been placed in the situation described to the "real-life" group, and (b) a description of the cards to be sorted in terms of their dimensions. The wording of this description was as follows:

> Bill thought he understood the instructions and turned his attention to the cards. He noted that each card had pasted on it two figures which varied in color, shape, size, and position. Looking further, he found that the figures were of five different colors (red, yellow, green, blue, and gray), three different shapes (triangles, squares, and pentagons), two sizes (small and large), and that in each case, one figure was pasted over the other. [Pp. 425-426]

The percentage of solutions for the textbook group was significantly higher than that for the real-life group. Although Marks and Ramond suggested that the difference could be attributed to a more analytical approach by subjects in the impersonal textbook situation, it is equally plausible that description of the stimulus material facilitated performance.

Pishkin (1965) has suggested that specification of the dimensions of concept instances may facilitate concept learning by reducing the set of hypotheses to be considered by the subject. To test this possibility, Pishkin devised a two-phase concept identification task. In Phase I, some subjects received correct feedback, while other subjects received misinformative feedback. In Phase II, all subjects were given a new concept learning problem. This problem had one relevant dimension, and either one, three, or five irrelevant dimensions.

During Phase II, half of the subjects were assigned to a dimensions available (DA) condition, the other half to a dimensions not available (DNA) condition. In the DA condition, the subject was given eight slips of paper on which were listed the stimulus dimensions. The subject was told that one of these dimensions would help him solve the problem, and was allowed to refer to the slips at any time during Phase II. In the DNA condition, the subject was simply told that he was to begin a new problem.

The number of errors to solution was significantly lower for subjects in the DA condition. This condition had a comparatively greater facilitating effect for subjects who had misinformative feedback during Phase I and for subjects given a problem with five irrelevant dimensions. Pishkin interpreted the results as supporting the hypothesis that specification of stimulus dimensions reduced the set of hypotheses to be tested.

A very similar experiment by Holstein and Premack (1965) did not yield a significant effect due to instructions. In this experiment, the concept had one relevant dimension, and either one or five irrelevant dimensions. Subjects were given 0, 6, 20, or 40 trials of misinformative feedback before receiving consistent feedback with regard to the relevant dimension. Half of the subjects received "vague" instructions which stated only that the cards could be sorted into two categories and that the experimenter would tell the subject whether his choices were right or wrong. The other half of the subjects received the same instructions but were, in addition, shown cards containing all values of the dimensions. The two values of each dimension were pointed out to the subject and he was told that the problem had a simple solution.

Unlike Pishkin (1965), Holstein and Premack found no significant difference in trials to criterion as a function of instructions. Note, however, a crucial difference in the methodology of the two experiments. Holstein and Premack gave their instructions before misinformative feedback, and proceeded to the concept problem without signal. Pishkin gave his instructions after misinformative feedback, and indicated that a new problem was to begin. Thus, in the Holstein and Premack experiment, any facilitative effects due to instructions may have been negated by the experience with misinformative feedback.

Klausmeier and Meinke (1968) compared performance for college-age subjects receiving instructions varying in purpose and amount of information. One group of subjects received a set of instructions giving minimal information. A second group of subjects received the minimal instructions plus the following information concerning the structure of the stimulus material:

> Now, let us examine the structure of the material. [The E points to the board.] There are 128 cards on this board. This slip of paper lists the attributes contained on each card on the board. Pick any one card on the board and point out the seven attributes, listed on your slip of paper, which are also on the card. Do your checking aloud so that I may follow you. Start with number of borders. [The E checks that S follows the sequence given on the slip and checks all attributes.] Do you understand that any card you would have chosen would have all the seven attributes? Do you have any questions on the seven attributes contained on each card? [Pp. 217-218]

A third group of subjects received the minimal and structure instructions, plus a description of a conservative focusing strategy. Subjects attained a series of conjunctive geometric concepts, each having three relevant dimensions, under a selection paradigm.

Using time to criterion as the dependent variable, a significant effect due to instructions was noted. Subjects with minimal instructions took the longest time, subjects with strategy instructions the shortest time. Although subjects having structure instructions took less time than subjects having only minimal instructions, the difference was not significant. It should be noted, however, that subjects in both the minimal and structure groups had slips of paper listing the seven attributes on which the stimuli varied. Thus, the minimal group also received some information concerning the structure of the stimulus material.

Dimensional information may also affect the strategy adopted by the subject in solving a concept identification problem. Johnson, Fishkin, and Bourne (1966) assigned college

students to reversal or interdimensional shift problem conditions. Half of the subjects in each condition received "simple" instructions which indicated that the subject was to name the correct category for each of a series of patterns presented to him; the other half of the subjects received "detailed" instructions which listed five possible dimensions, specified that the solution to the problem entailed one of them, and demonstrated a sample solution. When "simple" instructions were given, the reversal shift problem was solved significantly faster than the interdimensional shift problem. When "detailed" instructions were given, the difference between the two types of problem was not significant. Johnson, et al. inferred that the "detailed" instructions induced a hypothesis-testing strategy, resulting in equal performance on both types of shift.

The experiments which have been discussed thus far in this section have dealt with the effects of information concerning the dimensions on which stimuli vary. Tagatz (1963) explored the effect of a different kind of information concerning stimulus material. This information consisted of a set of seven rules which could be used to determine the concept membership or nonmembership of cards on an ordered figural board. For example, one of the rules was, "If a card outside of the focus row is an exemplar, the card at the intersection of the focus row and the column in which the exemplar is located is also an exemplar. This card can then imply other cards less variant from the focus card which must also be exemplars" (p. 34).

All subjects in the experiment received general instructions concerning the nature of the task and the dimensions on which the stimulus material varied. In addition, half of the subjects were given the seven rules relating concept membership of instances to position on the board. Following the instructions, subjects were to attain two concepts, having three and four relevant dimensions, from presented information. Time to criterion was significantly longer for subjects who had received the special instructions. In considering the negative effect of positional information, it should be observed that the problems could be solved purely on the basis of dimensional information contained in the presented instances. The positional information was redundant to the dimensional information. Dealing with this superfluous information while performing the task may have required extra time. It would be interesting to study the effect of positional information under a selection paradigm, where the information might be utilized to make a more efficient selection of cards to be tested.

Instructions Concerning Desired Response

Intentional concept learning is generally more efficient than incidental concept learning. Fredrick and Klausmeier (1968) have pointed out that concept attainment entails securing information from instances and noninstances and processing that information to determine defining attributes and rules. Subjects must be directed to engage in conceptual behavior, either by explicit instructions or by a meaningful verbal sign which indicates the existence of a concept. The many experiments which have examined the effect of instructions to induce a concept learning set have generally shown a facilitative effect.

An early experiment by Reed (1946) compared the effects of instructions to learn the names of concept instances (incidental) with instructions to learn both the names of concept instances and the meaning of the names (intentional). College students were presented with instances of six concepts, each represented by a different nonsense syllable. Each instance consisted of a set of four familiar English words, one of which belonged to the category symbolized by the nonsense syllable. The mean number of promptings required by subjects was one-third greater for subjects in the incidental group than for subjects in the intentional group. Further, 86 percent of the intentional group formed concepts based on logically related words, while only 67 percent of the incidental group formed such concepts.

A series of experiments by Podell (née Amster) has been based on the assumption that different processes of concept formation occur under incidental and intentional sets. Podell hypothesized that when intentional concept learning instructions are given, a deductive or "active search" strategy predominates. In this case, a large variety of examples would facilitate learning by permitting false hypotheses to be rejected in fewer trials than with a small variety. Under an incidental set to learn, no difference due to variety is predicted since a large variety might permit more efficient summation of correct associations, but a small variety would permit better recall of instances. Under intentional set, older children are expected to benefit from a large variety of instances. For younger children, no corresponding facilitation is expected, since the deductive reasoning process is not well-developed (Amster, 1966).

Podell (1958) presented college students with a figural concept having six relevant attribute values. Half of the subjects received incidental concept learning instructions,

directing them to make artistic judgments of the designs. The other half of the subjects received intentional concept learning instructions, directing them to notice the way in which designs in the same class were similar to one another. There were also two conditions of variety of instances, small variety (2 instances) and large variety (12 instances).

Subjects who had learned under intentional set were able to identify significantly more relevant attribute values than subjects who had learned under incidental set. There was a significant interaction between set and variety of examples, however, such that the superior performance was true only for subjects in the large variety condition.

In a later experiment, Amster (1965) compared intentional and incidental learning under conditions in which either one or two sets of stimuli were present. When only one set of stimuli was used, instances of the concept to be learned were alternated with blank slides. When two sets of stimuli were used, instances of the concept were alternated with photos of children. In the intentional condition, subjects were requested to notice the features in each concept instance and those common to all instances. In the incidental condition, subjects were directed to notice the features in each photo and those common to all photos, or to notice their thoughts while the screen was blank. Intentional learning was significantly better than incidental learning on three different measures: (a) total number of common features mentioned in a verbal definition, (b) number of common features in the first drawing of an instance following learning, and (c) number of common features that appeared consistently in three pictures drawn following learning.

Three experiments were carried out to clarify the interaction between set and variety of instances (Amster, 1966). In these experiments, children were taught concepts based on complex aggregates of features contained in flags. The dependent variable was accuracy in constructing a new flag to exemplify the concept. In the first experiment, subjects were kindergarten and fourth- and fifth-grade children. Intentional and incidental set conditions were compared under two conditions of variety, two instances or eight instances. Intentional learning was significantly superior to incidental learning for children at both age levels. The hypothesized interaction between set and variety did not occur. In the second experiment, additional irrelevant forms were added to the concept instances used in the first experiment. Subjects were fourth- and fifth-grade children. Again, intentional learning was significantly better than incidental learning, and there was no interaction between variety and set. In the third experiment, the stimulus material from the second experiment was used with kindergarten subjects. No significant effects occurred as a function of set, variety, or their interaction.

Shaffer (1961) presented British college students with 30 different sets of three polygons. For each set, the subject was instructed to order the polygons in terms of area. Subjects in one group were presented the task as simply one of area discrimination, and no mention was made of the possibility of finding a rule for solution. Subjects in another group were told: "By looking at various features of the polygons or of the cards generally you may be able to find some rule that will make it easier to produce the correct order. If there are such features and you can find a rule, by all means use it" (p. 363). When the task was completed, subjects were asked how they ordered the polygons and what features they examined. Error scores and responses to questioning indicated that the probability of discovering and using a rule was higher for subjects who had been instructed to search for a rule.

In a response selection task which closely resembled concept identification, DiVesta and Walls (1967) presented 80 word pairs, each consisting of an aggressive and a nonaggressive verb. The task required the subject to select one verb from each pair. Subjects were given one of four types of instruction prior to the task: (a) principle, in which subjects were told that the words had been prepared according to a definite principle and that their task was to select as many words as possible that would correspond to that principle, (b) word, in which subjects were directed toward the correctness of one of the words in each frame rather than toward a general principle, (c) extrasensory perception, in which subjects were directed to predict responses selected by other groups, and (d) control, in which subjects were told that it didn't matter which word they chose.

The dependent measure was departure from random selection. There was a significant effect due to instructions, with the principle group producing the largest number of rule responses and the word group the second largest number. Postexperimental interviews indicated that the percentages of correct behavioral hypotheses reported by the principle, word, extrasensory perception, and control groups were 75, 45, 40, and 17, respectively.

Two studies have been carried out which suggest that the effects of intentional and incidental instructions may be related to certain subject variables. Osler and Weiss (1962) hypothesized that when nonspecific instructions are given, a concept attainment task consists of two components, problem finding and problem solving. When specific instructions are given, the problem finding component of the task is eliminated, since the problem to be solved is defined.

To explore this possibility, Osler and Weiss compared concept attainment of 6-, 10-, and 14-year-old children stratified on intelligence, under conditions of nonspecific and specific instructions. Nonspecific instructions presented the task as a game in which the subjects could win marbles by pushing the correct handle, and that by looking at pictures (instances of the concept bird) before pushing the handle, they could win many marbles. Specific instructions were similar, except that subjects were told that "there is something in the pictures like an idea that will tell you which one to choose to get a marble every time" (p. 529).

It should be noted that nonspecific instructions were given in one experiment, specific instructions in another. Conclusions, therefore, are based on indirect evidence and should be validated by an experiment in which subjects are randomly assigned to instructional conditions. Under nonspecific instructions, high intelligence subjects had significantly fewer errors to criterion than average intelligence subjects. Under specific instructions, there was no significant effect due to intelligence. Osler and Weiss concluded that superior intelligence gave subjects an advantage in the problem finding component of the task, but not in the problem solving component.

A recent study by Laughlin, Doherty, and Dunn (1968) employed as subjects high school students stratified on the basis of sex, intelligence, and creativity (as measured by scores on the Remote Associates test). All subjects were given both an intentional and an incidental concept learning task. Ten sets of six words were presented. The subjects were told that four of the six words exemplified a concept. The intentional task consisted of determining that concept. At the completion of the intentional task, the subjects were told to try to recall the two words that were not part of the concept. These two words also exemplified a concept. Identification of that concept comprised the incidental concept learning task.

The mean number of concepts learned under both intentional and incidental conditions increased as a function of both creativity and intelligence. Both intentional and incidental learning were significantly higher for males than for females.

Additional evidence for the facilitating effect of intentional instructions was provided by Kalish (1966), Lynch (1966), and Fredrick and Klausmeier (1968). Each of these studies employed as one of its variables "optimal" versus "minimal" instructions. Optimal instructions were:

> In this experiment you are going to identify concepts that I have in mind. A concept in this experiment is used to classify sets of cards into two groups, one set belongs to the concept and the other set does not. Let's clarify further how we are using the term concept in this experiment. Here is a card with one large textured green square (slide). Suppose that I told you 'yes,' meaning the card belongs to the concept I have in mind. This would tell you that the concept might be large square, or one large, or one textured, or green textured, or any other combination of features of the card. You would need more cards, however, to tell exactly what the concept is. Suppose I presented a second card that was identical to the first one except that it had one small textured green square, instead of one large textured green square. If I told you 'no,' meaning this card does not belong to the concept, you could infer that all cards that are small do not belong to the concept. The third card I present might be identical to the first one except that it contained a circle instead of a square. I might tell you 'yes,' meaning it does belong to the concept. You would know that both circles and squares belong to the concept. Still other cards would be needed to tell exactly what the concept is. Thus, concepts in this experiment are combinations of the features of the cards and are used to classify sets of cards. After seeing a series of cards you can decide what the concept is; you can tell which cards do and do not belong to the concept. The label below each card will tell you which are in the concept.
>
> You are going to see slides which have geometric figures on them. Some of these figures will be circles and some will be squares. The figures can

be large or small, red or green, solid or textured. There can either be one circle or two circles, or one square or two squares on a slide. For example, look at this slide (slide). We could describe it as two, large, plain, green, square figures [Another slide might be this one (slide). It is one, small, textured, red, circular, figure.] Now will you please describe the next figure. (pause) We will show you a series of six slides. Please watch closely. We will ask you questions about them. Do not write, do not turn page now. [Fredrick & Klausmeier, 1968, p. 1340]

Minimal instructions consisted of only the last paragraph of the optimal instructions.

It will be noted that optimal instructions had two purposes: (a) to provide an intentional concept learning set, and (b) to provide a principle for processing the information contained in instances. Thus, effects due to optimal instructions cannot be attributed solely to intentional set.

The effectiveness of optimal instructions as compared to minimal instructions, however, is shown by the fact that the optimally-instructed group performed significantly better than the minimally-instructed group in all three experiments.

The only experiment which has failed to show a significant effect due to intentional concept learning instructions is that of Braley (1963). In this experiment, high school students attaining geometric concepts were given either "concept learning" or "problem solving" instructions. The concept learning instructions directed the students to "discover what it is that makes a card correct, that is, find those characteristics of the cards that you need to pay attention to so as to be able to select the correct card on each trial" (p. 156). The problem solving instructions were to "make a choice each time the two cards appear and the light will tell you whether or not you are correct. In this way you will discover what it is that you need to pay attention to so as to reach a point where you can turn on the light on each trial" (p. 156). The type of instructions did not significantly affect performance in this experiment nor in a subsequent experiment utilizing the same sets of instruction. In retrospect, this lack of effect is not surprising, since the two sets of instructions differed little from one another.

The research just reviewed has indicated that intentional concept learning instructions generally facilitate concept learning. Further research might profitably focus on the effect of instructions intended to establish a set to attain specific behavioral objectives (e.g., recognition of concept instances, recall of relevant attribute values, verbalization of the concept definition) on performance of these objectives.

Information Concerning Solution Strategy

Instructions which give a decision rule for utilizing the information in instances improve concept learning. To attain a concept, the subject must process the information embodied in instances to infer the relevant attribute values. Explicit rules for drawing these inferences might be expected to facilitate utilization of information and thereby concept learning itself. Archer, Bourne, and Brown (1955) were the first researchers to study the effect of providing such inferential rules. They instructed all subjects in the nature of a concept and the criterion for judging performance. In addition, half of the subjects received "analytic" instructions which gave two rules: (a) if two instances are in the same category and one dimension varies between the two instances, that dimension must be irrelevant, and (b) if two instances are in different categories and only one dimension varies between the two instances, that dimension must be relevant. On each of five successive days, college students were presented with instances of geometric concepts having two relevant dimensions and from one to five irrelevant dimensions. Analytic instructions did not reduce overall time to criterion or number of errors, but did reduce the variability of these measures. Further, analytic instructions were more facilitating with complex tasks than simple tasks.

Similar instructions were utilized in an experiment by Klausmeier and Meinke (1968). This experiment examined the interaction of instructions giving inferential rules with instructions describing the stimulus material and instructions giving a strategy for selecting instances. Three groups of subjects were formed, each receiving one of the following sets of information: (a) minimal task directions, (b) minimal task directions and information about structure of the stimulus material, and (c) minimal task directions, information about structure, and a strategy for selecting instances. In addition, half of the subjects in each of these three groups received a principle giving explicit rules for drawing inferences from the instances. Subsequent to the instructions, each

subject learned four geometric concepts. Each concept had three relevant and four irrelevant attributes. Time to criterion and number of card choices were both significantly less for subjects who received the principle. This was true regardless of the additional set of instructions given.

A more recent study by Dunham and Bunderson (1969) indicated that different cognitive abilities may be employed in concept learning as a result of instruction on inferential rules. High school student subjects were divided into two groups, one which received rule instruction and one which received no rule instruction. All subjects then learned a series of nine concepts. Concept learning scores for subjects in each condition were then correlated with scores on tests for the following cognitive abilities: induction, verbal comprehension, general and logical reasoning, and associative and span memory. Factor loadings of the problems on the cognitive ability factors were estimated by a factor extension procedure. Associative memory and induction were most important in the condition with no rule instruction, and general reasoning and induction in the rule instruction condition. This implies that rule instruction minimizes memory requirements but requires greater use of reasoning.

It should be noted that in the Dunham and Bunderson (1969) study, unlike that of Archer, Bourne, and Brown (1955) and Klausmeier and Meinke (1968), no overall facilitation of concept learning performance was noted due to rule instruction. This is probably due to the relatively simple problems employed, which had two relevant dimensions and only one irrelevant dimension. Archer, Bourne, and Brown had observed that facilitation by rule instruction was greatest on complex problems. This is congruent with Dunham and Bunderson's conclusion that the effect of rule instruction is to reduce memory requirements, since memory requirements are highest on complex problems.

Some additional evidence for the facilitating effect of rule instruction is offered by Kalish (1966), Lynch (1966), and Fredrick and Klausmeier (1968). As was previously discussed in the section dealing with instructions concerning desired response, these authors found that directions combining instructions to learn a concept with instructions about inferential rules significantly improved concept learning.

Under the selection paradigm, instruction in an appropriate strategy for selecting instances results in more rapid concept attainment. Wells and Watson (1965) presented college students with three disjunctive problems following either minimal instructions or training in use of a negative focusing strategy. The number of cards chosen before the subject could state the concept was significantly lower for subjects who had been trained in a negative focusing strategy.

In an experiment previously described, Klausmeier and Meinke (1968) compared performance of subjects given one of three sets of instructions: (a) minimal task directions, (b) minimal task directions and information about structure of the stimulus material, and (c) minimal task directions, information about structure, and a conservative focusing strategy for selecting instances. Subjects given the third set of instructions performed significantly better than subjects given the first set.

Byers, Davidson, and Rohwer (1968) hypothesized that a conservative focusing strategy facilitates concept learning by reducing memory requirements. To test this hypothesis, they examined the effect of presence or absence of conservative focusing instructions under two conditions: (a) stimulus-display memory, in which feedback lamps under tested instances remained lighted throughout the problem, and (b) no stimulus-display memory, in which the lamps went out immediately following the subject's response. The college student subjects were presented with a series of three problems varying in complexity. A significant interaction between strategy instructions and stimulus-display memory condition resulted. Conservative focusing instructions facilitated performance only when no memory aid was available. An additional result of interest was a significant interaction between strategy instructions and concept complexity. When conservative focusing instructions were given, performance remained the same as complexity increased. When no instructions were given, performance decreased markedly as complexity increased.

The effect of strategy instructions is less clear when a reception paradigm is employed. Tagatz (1967) instructed fifth- and sixth-grade students in one of two strategies. Instructions for a commonality strategy directed the child to give his entire attention to positive instances and explained that dimensions common to all positive instances were relevant to the concept. Conservative focusing instructions directed the child to attend to both positive and negative instances and explained that if only one dimension differed between a positive and negative instance, that dimension was relevant.

The children were presented with a series of four problems. For each problem, two positive and two negative examples were given.

Time to criterion was significantly less for subjects receiving commonality instructions. At the completion of all four problems, the subject was asked which cards he had used, in order to determine what strategy he had actually employed. From this questioning, it was learned that many children instructed in a conservative focusing strategy actually reverted to a commonality strategy. This indicates that a conservative focusing strategy may be difficult for children of this age.

In a later experiment, Tagatz, Walsh, and Layman (1969) instructed college-age subjects in either a conservative focusing or a commonality strategy. Prior to these instructions, the subjects were presented with either an information processing or a concept learning training task. The group which received the conservative focusing instructions following the concept learning training task did not perform as well as any of the other three groups. This was interpreted to indicate that conservative focusing was a more demanding strategy which resulted in lower performance unless preceded by training in information processing.

Information Concerning the Nature of the Concept

Instructions which contain information concerning the relevant attributes or conceptual rule increase speed of concept learning. Knowledge of the relevant attributes is more facilitative than knowledge of the conceptual rule. Haygood and Bourne (1965) pointed out that concept problems used in research have two major features, the relevant attributes and the conceptual rule which combines those attributes. To separate experimentally the identification of the relevant attributes and rule, Haygood and Bourne employed three instructional conditions: attribute identification (AI), in which the rule was described to the subject, but the relevant attributes were unknown; rule learning (RL), in which the relevant attributes were given, but the rule was not explained; and complete learning (CL), in which neither the relevant attributes nor the rule was given.

Haygood and Bourne presented conjunctive, inclusive disjunctive, joint denial, and conditional geometric concepts to college students under each of the three instructional conditions. The effect of instructions was significant, with CL yielding more errors to solution than AI, and AI more errors than RL. Furthermore, this order of difficulty was true for all four types of conceptual rules.

The effects of AI, RL, and CL instructional conditions were confirmed in two later experiments by Haygood and Devine (1967). These experiments utilized inclusive disjunctive and biconditional problems, and independently varied the proportion of positive instances and proportion of positive instances embodying both relevant attributes. Again, CL was more difficult than AI, and AI more difficult than RL, regardless of the rule or relative proportion of positive instance types.

Further evidence of the effects of information concerning the relevant attributes or conceptual rule was provided by Haygood and Stevenson (1967), and Looney and Haygood (1968). Haygood and Stevenson used three conceptual rules (conjunctive, inclusive disjunctive, and conditional) and three levels of irrelevant information (0, 1, and 2 irrelevant dimensions). Again, instructional effects were significant, with CL most difficult, AI intermediate, and RL easiest. The interaction between instructions and amount of irrelevant information was significant, with AI facilitating performance to a greater degree as irrelevant information increased. RL showed almost no decrement with increase in irrelevant information, as might be anticipated since relevant attributes were known. Looney and Haygood used two conceptual rules (conjunctive and inclusive disjunctive) and three levels of relevant information (2, 3, and 4 relevant dimensions). Again, CL was hardest, RL easiest. The interaction between instructions and amount of relevant information was significant, with RL and AI exerting a stronger effect as the amount of relevant information increased.

The facilitative effects of information concerning relevant attributes or rules has also been noted using verbal concepts with young children as subjects. DiVesta and Walls (1969) presented fifth-grade children with a series of five conjunctive or disjunctive concept learning problems. Each concept had two relevant dimensions, which corresponded to dimensions measured by the semantic differential. As in previous studies, CL was most difficult, RL least difficult. The effect of information was greatest on the first problem, becoming less important on succeeding problems.

Other types of information concerning the concept to be learned may also be facilitative. In the case of concepts based on a common associate of verbal stimuli, Underwood and Richardson (1956) discovered that instructions which suggested the type of characteristic (in this case, a sense impression) which was

relevant to the concept resulted in more rapid learning. Each subject was presented with 24 nouns, four instances of six concepts. Three sets of instructional conditions were compared: unrestricted (UR), in which subjects were told to respond in free association fashion and to vary their responses on each trial until they began to get some correct; partially restricted (PR), in which subjects were asked ways to describe common objects and were led by questioning to give a number of sense impressions; and completely restricted (CR), in which subjects were given the six responses which were correct. CR resulted in better performance than PR, which was, in turn, better than UR.

Instructions to Recall Relevant Information

Gagné (1965) hypothesized that recall of previously learned entities immediately prior to learning would facilitate acquisition. Only one experiment has been carried out related to this hypothesis. Namikas and Harris (1968) trained subjects prior to a concept identification task to sort cards into four categories. For different groups of subjects, the words on these cards were relevant, irrelevant, or neutral with regard to the subsequent concept identification task. Immediately prior to the concept identification task, subjects were told either that the new task was related to the old task or that it was not related. The concept identification task consisted of a modification of the Wisconsin Card Sorting Test. A highly significant interaction between type of training and instructional set was observed. When subjects were told that the two tasks were related, relevant training increased concept learning, while irrelevant training decreased it. When subjects were told that the two tasks were not related, previous training did not affect concept learning. Thus, it was the set to utilize prior learning rather than the learning itself which was crucial.

Instructions Related to Level of Motivation

Several different types of instructional manipulations will be grouped together under the general heading of "motivation." These will include speed or accuracy instructions; ego-involved, task-involved, or competitive instructions; and monetary or symbolic incentives. The effects of speed instructions have been significant and consistent. The other variables have proven less effective.

Speed vs. Accuracy Instructions

Subjects given instructions to attain concepts as quickly as possible learn concepts faster than subjects given instructions to attain the concepts with as few errors as possible. The two groups, however, do not differ in number of errors. Laughlin (1964) compared performance of college students attaining a series of concepts under two instructional conditions: speed, in which subjects were instructed to attain the concepts as quickly as possible regardless of the number of card choices; and accuracy, in which subjects were instructed to attain the concept in as few choices as possible regardless of time. The speed and accuracy groups did not differ significantly on number of card choices to solution, but the speed group was significantly faster on time to solution.

A similar experiment was carried out by Siegel (1964) who also found no differences in trials to criterion under speed or accuracy instructions, but significantly lower latencies under speed instructions.

A study by Kagan, Rosman, Day, Albert, and Phillips (1964), however, indicated that for certain tasks, speed instructions may decrease accuracy. Kagan, et al. administered a Design Recall Test, Hidden Figures Test, and the Vocabulary scale of the WISC to second-grade children under either "slow" or "fast" instructions. Children given the "slow" instructions were significantly more likely to select the correct figure initially on both the Design Recall Test and Hidden Figures Test. Vocabulary scores, on the other hand, were not affected by instructional set. Kagan, et al. suggested that "slow" instructions caused the children to reflect before responding, thereby producing more analytic concepts. Better performance under "slow" instructions is predicted only when there is a high probability that a response will change upon reflection. It should be noted that the instructional sets used in this experiment were not directly comparable to those of Laughlin (1964) and Siegel (1964) since neither set stressed accuracy.

Ego-Involved, Task-Involved, or Competitive Instructions

Three studies have attempted to manipulate motivational set by giving instructions which

were designed to influence the subject to believe that the experimenter was interested in: (a) the task itself, (b) the subject's performance, or (c) the subject's performance in comparison to the performance of other subjects. No clear conclusions are possible from these studies.

Marks and Ramond (1951) compared performance of subjects given instructions to solve a task (ego-involved instructions) with performance of subjects given instructions to help a fictitious person solve a task (task-involved instructions). Although performance of subjects under task-involved instructions was significantly better than that of subjects under ego-involved instructions, this may have been due to additional stimulus familiarization given to the task-involved group.

A second study comparing task- vs. ego-involved instructions was that of Laughlin, Doherty, and Dunn (1968). In this case, task-involved instructions stated that the experimenter was not interested in individual scores, but in gathering information to improve the test. Ego-involved instructions stated that the test would tell the experimenter a great deal about the subject's abilities. Although there were no main effects due to motivational instructions, there was a highly significant interaction between instructions and sex for incidental concept learning. Males performed better under ego-involved instructions, females under task-involved instructions. Laughlin, et al. took this result to indicate that females have a higher habitual motivational level than males, and further external motivation, therefore, hindered performance. For males, however, this external motivation facilitated performance.

Kalish (1966) compared ego-involved and competition instructions and found no significant difference in concept learning performance.

Monetary or Symbolic Incentive Instructions

Three studies have examined the effect of promised incentives on concept attainment. Kalish (1966) gave instructions giving a high monetary incentive ($0.00 - $2.50, depending on performance) or a low monetary incentive ($0.00 - $1.25, depending on performance). No clear differences were noted as a result of level of incentive. It is possible that the two levels of monetary incentives were not perceived as greatly different by the subjects, who were college students.

Similarly, Bourne, Guy, and Wadsworth (1967) utilized four combinations of monetary incentives for performance on a card sorting task: RP, in which subjects won 2 ¢ for each correct response and lost 2 ¢ for each incorrect response; R, in which subjects won 2 ¢ for each correct response and lost nothing for incorrect responses; P, in which subjects won nothing for correct responses and lost 2 ¢ for each incorrect response; and S, in which subjects neither won nor lost any money. Like Kalish, Bourne et al. used college students as subjects and found no effect due to incentive.

Monetary-incentive, symbolic-incentive, and no-incentive conditions were compared by Fang (1966) using junior high school subjects stratified according to socioeconomic level. In this case the monetary incentive was $1.00 and the symbolic incentive was a certificate with the legend "Wisconsin Better Student Award." There was no significant effect due to incentive and no interaction between socioeconomic level and type of incentive. A posttest questionnaire indicated that all subjects had been highly motivated to do their best. Thus, offering an incentive could have had little additional effect. Fang speculated that incentives might have a more potent effect on performance of long-term or monotonous tasks.

Summary

It is apparent that verbal instructions given to the subject prior to concept learning may have powerful effects on acquisition. Several types of information may be included in instructions in order to facilitate learning. The dimensions on which concept instances vary should be explicitly indicated. Subjects should be made aware that a concept is to be learned, rather than simply being presented with the stimuli. Strategies for selecting instances and rules for utilizing information contained in the instances should be provided. Information concerning the relevant attributes and conceptual rule should be given. The consistently strong effects of instructions suggest that careful thought should be given to the nature of directions in any concept learning task. Furthermore, it is probable that instructions could be used to influence concept learning in the educational setting. For example, instructions might be given to familiarize children with characteristics of concept examples, to encourage them to adopt new strategies, or to work more quickly.

Evidence for the effect of introductory material on the learning of prose material similar to that used in classrooms has been provided by Ausubel (1963), Frase (1969), and Rothkopf (1966). Although these studies deal with a somewhat different type of learning than the laboratory concept learning research reported in this chapter, instructions again are found to have a facilitative effect. The similarity of results for concept learning and prose learning lends support to the prediction that instructions can be effectively employed to facilitate concept learning in the classroom.

III
Temporal Factors

Information processing is crucial to concept attainment. The length of time allotted each aspect of concept presentation may facilitate or hinder such information processing. Sufficient time is required for the subject to attend to the concept instances, formulate hypotheses, and draw inferences. Longer intervals, however, may result in forgetting.

When concept instances are presented successively with feedback, five time intervals may be identified: (a) stimulus exposure time, the period during which the concept instance is displayed to the subject; (b) preresponse interval, the interval between removal of the instance and the subject's response; (c) delay of informative feedback, the period between the subject's response and presentation of feedback; (d) postfeedback interval, the interval between presentation of feedback and display of the next instance; and (e) intertrial interval, the interval between successive presentations of a group of instances. Each of these intervals may be varied independently and the effects may be expected to differ depending on the nature of the concept and the information processing required during the interval.

Stimulus Exposure Time

Increasing stimulus exposure time beyond a critical minimum facilitates concept learning. To evaluate the effect of stimulus availability, Bourne, Goldstein, and Link (1964) allowed 0, 4, 6, 8, or 10 previously presented instances to remain in view of the subjects. The subjects, who were introductory psychology students, were required to learn a geometric concept with three relevant attributes. Performance improved with stimulus availability up to 4, but then worsened slightly. Bourne, et al. hypothesized that this decrement in performance was due to the fact that the 15-second response interval which had been allowed was not sufficient to inspect and utilize all available information. To test this hypothesis, they compared performance of subjects under three availability conditions (0, 4, and 8) and two lengths of response interval (15 seconds and unlimited). Again, subjects who were given only 15 seconds to respond showed a decrease in performance when allowed to inspect more than four stimuli. Subjects given unlimited time to respond showed consistently improved performance as availability increased.

Miller and Davis (1968) conducted two experiments to test the effect of stimulus exposure time on recall of information concerning instances as well as its effect on concept identification. In both experiments, introductory psychology students were presented the minimum number of instances necessary to define a geometric concept. After the last instance had been shown, the subjects were asked to describe the concept and recall the values and category (positive or negative) of each instance which had been presented.

In one experiment (Miller & Davis, 1968), subjects were presented instances of concepts having one or three relevant attributes with exposure times of 5, 10, or 15 seconds. Recall of both values and categories was linearly related to increasing amounts of stimulus exposure time. The effect on concept identification, however, was not significant.

In another experiment (Miller & Davis, 1968), instances were presented either simultaneously or successively, with stimulus exposure times of either 5 or 15 seconds per instance (in the simultaneous condition all instances were displayed for a length of time equal to the total length of time required to display the instances in the comparable successive condition). The 15-second stimulus exposure time resulted in superior concept identification and recall of instance values and categories for both simultaneous and successive presentation.

Further evidence of the effect of stimulus exposure time was provided by Remstad (1969). Applying response surface methodology to the optimization of concept learning performance, Remstad carried out a sequence of experiments varying a combination of independent variables. One of these independent variables was the length of time the instances were available to the subjects, 8 seconds or 12 seconds. Fifth-grade children were used as subjects and the concepts to be learned were plane geometric figures. Although response surface methodology does not test hypotheses concerning the effect of individual variables, the increase in stimulus exposure time from 8 to 12 seconds produced one of the largest increases in mean correct instance identifications of any individual variable.

Thus, there is evidence that an increase in stimulus exposure time facilitates concept attainment. The Miller and Davis (1968) studies suggest that at least part of this effect may be due to better retention of instances. Although the optimal stimulus exposure time probably varies with the complexity of the stimulus and characteristics of the subject, it is clear that precautions should be taken to allow sufficient time for inspection of the stimulus.

Preresponse Interval

Roweton and Davis (1968) predicted that lengthening the preresponse interval might allow information-processing activities such as relating one or more current hypotheses to information provided by the stimulus or selecting a response consistent with both the stimulus and the hypotheses. To test this prediction, Roweton and Davis required the subject to delay his overt response until signaled by the experimenter. Undergraduate college students served as subjects and were required to learn geometric concepts having two relevant dimensions and either two or four irrelevant dimensions. The three preresponse intervals investigated were 0, 10, and 20 seconds. Performance improved as a function of length of the preresponse interval. The effect was particularly evident with the more difficult problems.

Although a generalization cannot be drawn on the basis of a single study, it appears that duration of the preresponse interval is an effective variable. Further studies might be carried out to clarify the nature of the information-processing activities taking place during this period.

Delay of Feedback

A short, unfilled delay interval preceding feedback has little or no effect on concept attainment. If feedback is not provided immediately following removal of the stimulus, one might expect that concept learning would be retarded due to loss of some of the stimulus characteristics through forgetting. This expectation, however, has not been supported by experimental results.

Bourne (1957) varied the delay interval between stimulus removal and informative feedback in an experiment which required subjects, undergraduate college students, to identify conjunctive concepts based on two relevant dimensions of geometric stimuli. Delay intervals used were 0, .5, 1, 2, 4, and 8 seconds. Mean number of errors increased as a positively accelerated function of the length of delay interval.

However, a later study (Bourne & Bunderson, 1963) replicated part of Bourne's 1957 study with results that indicated that the observed decrement in performance was probably due to decreased postfeedback interval rather than increased delay interval. In the 1957 study, postfeedback interval had been decreased as the delay of informative feedback interval increased, in order to keep the interstimulus interval constant. When postfeedback intervals were equated, delay of informative feedback did not have a significant effect on performance as reflected by total errors to solution.

Longer delay intervals were employed by Sax (1960). His task required high school students to associate Chinese characters with nonsense syllables. Five idiographs (characters plus irrelevant cues) were associated with each nonsense syllable. Informative feedback was provided by onset of a green light following each correct response. Two percentages of reinforcement (50 and 100) and four delay-of-feedback intervals (0, 10, 20, and 40 minutes) were combined factorially, yielding eight experimental conditions. The only significant difference in learning rate was between the 50 percent reinforcement - 0 delay and the 100 percent reinforcement - 40 minute delay groups, with the latter group requiring a greater number of trials to reach criterion. A retention test two weeks after acquisition revealed no significant differences between the experimental groups. Sax did not specify in what type of activity the subject engaged during the delay interval. It may be inferred from the nature of the stimulus material, however,

that incidental activity was not related to the experimental task.

Postfeedback Interval

Improvement in concept learning performance occurs as the length of the postfeedback interval increases. The postfeedback interval is defined as the time interval which separates the informative feedback following a response and the presentation of the next stimulus. It has been found that lengthening this interval generally has a facilitative effect, possibly because it allows the subject time to draw inferences from both the stimulus and the feedback which occurred on the trial. If the postfeedback interval is extended beyond a certain optimal length, performance diminishes, probably due to forgetting of stimulus information (Bourne, 1966).

Bourne and Bunderson (1963) varied the postfeedback interval (1, 5, or 9 seconds) in a task which required college students to identify a conjunctive geometric concept with two relevant dimensions and either one or five irrelevant dimensions. There was a decrease in number of errors as the postfeedback interval length was increased. Bourne, Guy, Dodd, and Justesen (1965) extended this study using the same procedures, but with postfeedback intervals of 1, 9, 17, or 25 seconds. Performance improved, then worsened with increases in length of the interval. The optimal length for one irrelevant dimension was 9 seconds, for five irrelevant dimensions, 17 seconds.

To test the hypothesis that the decrement which occurred with intervals of 20 to 30 seconds was due to forgetting, Bourne, et al. (1965) conducted a second experiment wherein either the stimulus pattern, the feedback signal, or both were present during the interval. Three interval lengths were studied: 1, 15, and 29 seconds. Performance did not deteriorate even with a 29-second interval when the stimulus patterns remained available to the subjects. Differences due to presence or absence of feedback were not significant.

Roweton and Davis (1968) also studied the effect of increasing the length of the postfeedback interval. As in the Bourne experiments just described, college students were required to identify conjunctive geometric concepts with two relevant dimensions, but two or four irrelevant dimensions. Trials to criterion decreased as the postfeedback interval was increased from 0 to 20 seconds.

Within a hypothesis selection framework, learning is thought to be a response-dependent process, and occurs only on error trials. From this viewpoint, the effect of varying the postfeedback interval would be limited to error trials. Within a cue-conditioning framework, on the other hand, learning is thought to occur on all trials and the influence of interval length would, therefore, occur on all trials. To test these contrasting predictions, Bourne, Dodd, Guy, and Justesen (1967) employed a geometric conjunctive concept problem with two relevant and four irrelevant dimensions. The postfeedback conditions were the four possible combinations of 1 and 15 second intervals after correct and incorrect responses. Performance, as judged by correct responses, indicated that there was learning on all trials rather than on error trials only. Performance improved when there were some long intervals, and was best when there were long intervals on all trials.

Intertrial Intervals

Intertrial intervals up to 60 seconds do not facilitate concept learning. Over a ten-year period, Underwood and his associates carried out a series of studies dealing with the influence of distributed practice on verbal learning. From this program of research, a set of critical variables emerged and a theory was posited to account for the effects of these variables (Underwood, 1961). In this theory, verbal learning is viewed as occurring in two stages. The first stage is the response learning stage during which the learner must acquire the responses as "readily recallable units." The second stage is the associative stage during which the responses must be attached to particular stimuli. Underwood (1961) concluded that distributed practice will facilitate learning only when there is interference operating during the response learning stage. Practice which is distributed such that the rest interval between trials is within certain limits tends to extinguish the interfering responses.

Although most studies of distributed practice have focused on verbal learning tasks, certain factors suggest that distributed practice might also affect concept learning. Underwood (1966), in fact, pointed out that concept learning might be thought of as a variant of an A-B, C-B verbal learning paradigm in which different stimuli are assigned the same response. On the other hand, associating one response with more than one stimulus would be expected to lead to greater associative interference, and less response interference than the usual A-B, C-D paradigm.

To study the effect of length of intertrial interval, Oseas and Underwood (1952) presented college students with instances of nine geometric concepts labeled by single consonant letters. A trial was counted as the presentation of nine successive stimuli, one instance for each of the nine concepts. Four lengths of intertrial interval were compared: 6, 15, 30, and 60 seconds. Performance was slightly better for the distributed conditions (15, 30, or 60 seconds) than for the massed condition (6 seconds), but the difference was not significant.

Richardson and Bergum (1954) essentially replicated the Oseas and Underwood experiment, but presented the concept instances at a faster rate (2 seconds instead of 3 seconds) and used different irrelevant dimensions to vary the difficulty of the lists. Intertrial intervals of 4 seconds and 30 seconds were employed. Again, no significant differences due to distribution of practice were found. It was noted, however, that distribution of practice facilitated learning most in the group that had the least difficult list.

Logically, the concept learning task may be divided into three stages: (a) identifying the dimensions and values, (b) discovering which dimensions are relevant to the concept, and (c) associating the concepts with their label. Richardson and Bergum (1954) designed a second experiment to isolate the three stages experimentally and to determine the relative contribution of each stage to the total task. Stage 3, which is rote learning, accounted for 88 percent of the total trials to learn. The interpretation made by Richardson and Bergum was that the least difficult list had the largest component of rote learning and was facilitated most by distributed practice.

The interaction of length of intertrial interval and task complexity was explored by Brown and Archer (1956). Geometric concepts having 2 relevant and 0, 2, 4, or 6 irrelevant dimensions were presented to college students with intertrial rests of 0, 30, or 60 seconds. Neither the main effect of distribution of practice nor the interaction with task complexity was significant.

To test the generality of the conclusion that distributed practice has little or no effect on concept learning, Underwood (1957) used verbal rather than figural stimuli. Three lists of concepts were constructed, differing only in degree of overlap of descriptive characteristics for different concepts. Intertrial intervals were 4 or 30 seconds. No differences in learning occurred as a function of length of intertrial interval.

Summary

The length of time allotted each aspect of concept presentation has been shown to affect learning. Of particular importance are adequate allotments for stimulus exposure time and postfeedback interval. Manipulation of temporal factors is a powerful technique for investigating the cognitive operations taking place during concept learning. Since the critical intervals are so short, the influence of these factors is probably minimal in the classroom setting. If the use of automated teaching becomes more prevalent, however temporal factors may come to have considerable importance.

IV
Informative Feedback

Informative feedback exerts a powerful effect on concept learning. In general, the learner has three sources of information when attempting to form a concept: verbal directions, stimuli, and informative feedback. Variations in any of these may accelerate or decelerate learning. Directions may describe the nature of the stimuli or suggest ways of utilizing information contained in the stimuli or feedback. The stimulus provides cues regarding the correct response on a given trial, while feedback provides information regarding the way the subject should respond on future trials.

Feedback provides information to the learner concerning the correctness of his responses. In addition, it may have motivational effects. Feedback may be given regarding an individual response, a hypothesis offered, or overall performance.

Informative Feedback Variables

Type of Feedback

In general, the experiments summarized in this paper utilize one of two methods for presenting feedback, verbal comment by the experimenter or onset of lights. Other techniques, such as sounding a buzzer or presenting the subject with a token, have occasionally been employed. Any event which provides the subject with information concerning the correctness of his responses may be considered to be feedback. It is probable, however, that different types of feedback provide different amounts of information to the subject, and evoke different responses from him. Therefore, comparisons between methods of presenting feedback should be undertaken.

To date, only one such comparison has been made in the field of concept learning. Wallace (1964) compared verbal feedback with a buzzer signal and found that differences existed between the two. Mild verbal feedback resulted in less hypothesis-offering behavior than did a just-discriminable auditory signal. Hypothesis behavior varied with the intensity of the auditory signal but remained constant when the intensity of verbal feedback was altered.

Confirming vs. Disconfirming Feedback

Performance in concept identification tasks is equivalent whether feedback is given after both correct and incorrect responses or after incorrect responses only. Performance is impaired, however, when feedback is given after correct responses only. One might anticipate that performance in a concept identification task would be best when the subject is given feedback after both correct and incorrect responses. If feedback is provided after correct responses only or after incorrect responses only, less information is conveyed, and a decrement in performance would be expected. This expectation has not been confirmed by experimental results. Instead, it appears that feedback after incorrect responses only will lead to performance equivalent to that obtained with feedback after both correct and incorrect responses. Both of these conditions are superior to feedback after correct responses only.

Buss and Buss (1956) studied the effect of three different verbal feedback combinations on concept identification of neuropsychiatric patients using the Wisconsin Card Sorting Test. The verbal feedback combinations were: "right" for a correct response, "wrong" for an incorrect response (R-W); nothing for a correct response, "wrong" for an incorrect response (N-W); and "right" for a correct response, nothing for an incorrect response (R-N). Subjects were required to learn first

a shape concept, then a color concept. No conclusions concerning learning of the shape concept could be drawn, since almost all subjects began sorting for shape immediately, and received only the designated reinforcement for a correct response. In learning the color concept, the R-W and N-W groups learned significantly faster than the R-N group.

In an attempt to test the generality of these findings, Buss and Buss (1956) conducted a second experiment in which student nurses as well as neuropsychiatric patients served as subjects. Only the R-W and N-W reinforcement conditions were utilized, and subjects were tested on two concepts, number and color. Again, the R-W and N-W groups did not differ significantly in the rate at which they attained new concepts. These results were interpreted as indicating that "right" is a much weaker positive reinforcer than "wrong" is a negative reinforcer.

Results discrepant from those of Buss and Buss were obtained in an experiment by Pishkin and Wolfgang (1965). Elementary psychology students identified concepts using the Wisconsin Card Sorting Test under R-N, N-W, or R-W feedback conditions. Under conditions comparable to those of Buss and Buss, no significant differences were noted among the three feedback groups. The only apparent methodological difference between the two studies was that Buss and Buss employed a criterion of ten consecutive correct responses, while Pishkin and Wolfgang required verbalization of the correct solution.

Meyer and Seidman (1960) also compared R-W, R-N, and N-W reinforcement combinations, but used as subjects children 4-5 and 8-9 years old. The stimuli were nine pairs of three-dimensional geometric blocks in the shape of cylinders, triangles, and rectangles. The color and height of these blocks were constant, but the basal surface area differed for members of each pair. Rank order of treatment effectiveness was R-W, N-W, R-N for the preschoolers and N-W, R-W, R-N for the older children. The differences between treatments were not significant. It should be noted, though, that R-N was the least effective reinforcement combination at both age levels.

Later, Meyer and Seidman (1961) replicated part of this study by comparing the R-W and N-W conditions. Stimulus materials were the same as in the previous study and subjects were chosen from the same age groups. Again, R-W and N-W conditions were found to be equally effective.

Meyer and Seidman (1960) concurred with Buss that combinations of feedback including "wrong" are more effective than those which do not include it. They offered two alternative interpretations for this finding: (a) punishment increases drive, (b) "wrong" is a stronger negative reinforcer than "right" is a positive reinforcer. Meyer and Seidman also suggested that negative reinforcement may be crucial in order to establish appropriate discriminations during learning. Positive reinforcement may improve performance once these discriminations have been established.

Bourne (1966) pointed out that Buss' findings may have been due to the fact that "wrong" would occur more frequently than "right" during learning. Since Buss employed a four-response problem, the probability of an incorrect response was three times greater than that of a correct response. Thus, the average percentage of trials with feedback varied among the conditions: R-W = 100%, N-W = 75%, and R-N = 25%. To explore the possibility that differences in performance occurred because of differences in the frequency of feedback, Bourne, Guy, and Wadsworth (1967) compared the effects of R-W, N-W, and R-N feedback on both total trials and total feedback trials. Results based on total trials were in agreement with those of Buss and Buss (1956) and Meyer and Seidman (1960, 1961)—R-W and N-W required fewer total trials than R-N. On total feedback trials, however, the three conditions were equivalent. This lends support to Bourne's contention that frequency of feedback was the variable which accounted for the differences between R-W, N-W, and R-W conditions. On the other hand, in Meyer and Seidman's studies only two responses were possible, rendering "right" and "wrong" equally probable.

Another interpretation of the superiority of R-W and N-W over R-N feedback suggested by Bourne was that "wrong" is less ambiguous than "right" since it definitely indicates that the subject has not attained the concept. "Right," on the other hand, may indicate either concept attainment or a correct guess. A similar explanation of the observed equivalence of the R-W and N-W conditions has been proposed by Levine, Leitenberg, and Richter (1964) in the "blank trials law." This theorem equates behavior after the experimenter says "right" with behavior after blank trials (trials on which no feedback is given). Two assumptions underlie the theorem: (a) the unit of behavior directly affected by the outcome procedure is the subject's hypothesis and (b) "rights" and blank trials produce no changes in the subject's hypothesis and are therefore equivalent in their effect on the subject's behavior.

When feedback is given only after incorrect responses during acquisition, extinction is slower than when feedback is given after both correct and incorrect responses or correct responses only. Following acquisition, Meyer and Seidman (1960) immediately tested subjects on an extinction series during which the experimenter did not respond to the subject's choices. Stimuli employed were similar to those used during acquisition, but differed in height. The group which during acquisition was given feedback after incorrect responses only (N-W) performed significantly better during extinction than did groups who were given R-W or R-N feedback. In fact, the N-W group continued to improve after the first block of extinction trials.

Results of Meyer and Seidman's later study (1961) were similar. During extinction, the N-W group showed little decrement in performance, while the R-W group exhibited a typical extinction curve.

The authors believed that these findings concerning extinction indicated the possibility that "nothing" had acquired positive reinforcement value when paired with "wrong." Thus, each response made by subjects in the N-W group during extinction would, in effect, be reinforced. When paired with "right," "nothing" may have gained negative reinforcement value, and would actually interfere with the previously learned responses of the R-N group. The R-W group would have had no experience with the experimenter's lack of response.

Completeness of Feedback

Under some conditions, increasing feedback completeness facilitates concept learning. Three types of feedback which differ in the amount of information provided have been utilized in concept identification experiments. The most frequently employed type of feedback simply informs the subject whether his response was correct or incorrect. A second type of feedback informs the subject whether his response was correct or incorrect, and when incorrect, indicates the correct response. A third type of feedback provides the subject with an explanation of the reason his response was correct or incorrect.

Since the latter two types of feedback provide the subject with more information than the first type, it would be expected that they would lead to more rapid concept identification. There have been few experimental studies dealing with completeness of feedback, and the outcomes of these experiments are somewhat contradictory.

Bourne and Pendleton (1958) studied the identification of conjunctive geometric concepts by college students. The concepts to be identified consisted of two relevant dimensions and either one, three, or five irrelevant dimensions. Two degrees of feedback completeness were used. In the first condition (incomplete feedback), the subject was informed merely whether his response was right or wrong by the onset of a feedback light. In the second condition (complete feedback) the subject was informed whether his response was right or wrong by a feedback light and, in addition, another light indicated the correct response key. Performance was significantly better for the subjects who were given complete feedback. The superiority of the complete feedback condition over the incomplete feedback condition held over all levels of task complexity.

Della-Piana (1957) used experimental conditions similar to those of Bourne and Pendleton. Della-Piana, however, hypothesized that incomplete feedback would induce a "searching orientation" in the learner, wherein he would attempt to discover why a response was incorrect. Complete feedback, on the other hand, would be expected to induce a lesser degree of searching behavior. Based on this analysis of the effects of feedback, Della-Piana predicted that subjects given incomplete feedback would learn concepts faster and be able to define the concepts more often than subjects given complete feedback. Like Bourne and Pendleton, Della-Piana required his subjects to learn geometric concepts, but these concepts were based on affirmation of a single attribute and the response required was a nonsense syllable which was to be associated with the concept.

Although subjects in the incomplete feedback group were able to define more of the concepts which they had correctly named than were subjects in the complete feedback group, no significant differences were found between the incomplete and complete feedback groups in speed of concept learning. Bourne and Pendleton found differences in learning speed favoring the complete feedback group. The discrepancy in outcomes may be explained by the fact that Della-Piana used verbal rather than mechanical feedback. Following an incorrect response, subjects in the incomplete feedback group were told to keep trying until they discovered the correct answer. This instruction may have had a motivational effect which compensated for the lesser amount of feedback information.

Indirect evidence for the facilitative effect of corrective feedback derives from comparison

of two studies by Pishkin (Pishkin & Wolfgang, 1965; Pishkin, 1967). In both studies, college students were given a four-choice Wisconsin Card Sorting Test. In the first study, the subjects' errors were not corrected; in the second study, the subjects' errors were feedback-corrected. For comparable conditions, number of errors to criterion were less for subjects given corrective feedback.

In a study dealing with formation of concepts in general psychology, Ter Keurst (1964, 1965) provided programmed material related to course content. Three types of feedback were employed: (1) no feedback, (2) right-wrong feedback, and (3) explanatory feedback which indicated whether a response was right or wrong, and why. Performance on departmental tests was better for students who received feedback than those who did not, but no clear differences emerged between explanatory and nonexplanatory feedback.

The possibility exists that the effect of corrective feedback is related to task difficulty. Milgram and Furth (1967) required elementary school children, ages six and nine, to choose two pictures representing a part-whole concept from sets of five pictures. Three experimental groups were formed: (a) no corrective feedback, (b) corrective feedback only on easy items, and (c) corrective feedback only on difficult items. Corrective feedback had a slight facilitative effect on concept attainment, but only for the nine-year-olds. Also, nine-year-olds given correction only for the more difficult items did not do as well overall as the children who had been given correction only on the easier items.

Wittrock and Twelker (1964) studied the effect of feedback on the learning, retention, and transfer of rules for decoding enciphered sentences. They found that the groups who were given feedback performed better on all three measures. This difference is particularly noteworthy, since some intrinsic feedback was available to both groups due to the fact that correctly decoded sentences were meaningful.

The outcomes of studies dealing with completeness of feedback clearly indicate that the presence of feedback facilitates learning. It is unclear. however, whether providing a subject with the correct response or explanation concerning the correctness of his response increases learning beyond the level induced by right-wrong feedback only. Further study is required to determine under what conditions corrective feedback facilitates concept learning.

Number of Trials with Feedback

Increasing the number of trials with feedback improves performance on a criterion series with no feedback. Performance on a subsequent task is also improved. As the number of trials with feedback increases, one would expect the correct mode of response to be learned more completely. Degree of learning can be measured by the tendency to respond appropriately to stimuli in the absence of feedback. Another measure of degree of learning may be obtained by switching the concept without the subject's knowledge. The more thoroughly the subject has learned the first concept, the more likely he is to notice the switch.

Buss (1950) used a block-sorting task to study the effect of number of trials. During the learning series, blocks were sorted on the basis of height, tall or short. The college students who served as subjects were divided into five groups which differed in the relative number of tall and short blocks presented during learning. The number of correct responses to a given height of block during a criterion series increased as a function of the number of times it had been presented during the learning series.

Grant conducted two experiments dealing with ease of concept-shifting as a function of trials on the first concept. In the first (Grant & Berg, 1948), college students were given the Wisconsin Card Sorting Test. Following a specified number of correct responses, the sorting category was changed without the subjects' awareness. This procedure was repeated, until a total of five switches had been made. Seven experimental groups were formed, which differed in the number of correct responses before switching: 3, 4, 5, 6, 7, 8, or 10, respectively. As the number of correct trials before switching was increased, perseverative errors decreased, and the new correct response was attained more readily.

In the second experiment (Grant & Cost, 1954), the same procedure was followed, but the experimental treatments were changed to study the effect of a larger number of correct trials before switching. Four groups were formed, having 5, 10, 20, or 40 correct trials before switching. Again, it was found that performance on the new task was better following 10 trials on the first task than following 5 trials. No significant differences were found, however, between the performance of groups having 10, 20, or 40 trials.

Probability of Feedback

Performance on concept identification tasks is improved as the percentage of trials on which feedback occurs is increased. Several experimenters have studied the effects of omitting

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feedback on some of the trials in a concept identification task. Carpenter (1954) required graduate students to sort Vigotsky blocks into two classes and provided four degrees of feedback: (a) on 25 percent of correct trials, (b) on 50 percent of correct trials, (c) on 100 percent of correct trials, and (d) on 100 percent of correct trials and on 100 percent of incorrect trials. He found that concepts were attained in less time as the percentage of feedback increased.

Bourne and Pendleton (1958) conducted a similar study, requiring college students to identify conjunctive concepts based on two relevant dimensions. Four levels of feedback were used—100, 90, 80, and 70 percent—and task complexity was varied by using one, three, or five irrelevant dimensions. The mean number of errors increased as percentage of feedback decreased, and the number of errors was an increasing function of task complexity.

In an experiment utilizing a modified Wisconsin Card Sorting Test and college students as subjects, Erlebacher and Archer (1961) also studied the effect of varying percentage of feedback trials. The levels studied were 25, 50, and 100 percent. As the percentage of feedback increased, number of correct responses, number of errors, and total number of responses decreased (on the Wisconsin Card Sorting Test, decrease in these measures indicates improved performance).

O'Connell (1965) used a card sorting test with geometric figures which varied along four dimensions. His subjects, who were college students, were required to sort the cards and, in addition, give the reason for their placement. During acquisition, half of the subjects received 100 percent feedback and half 60 percent feedback until each reached 50 trials with feedback. Both the number of correct placements and number of correct reasons were higher for the group under 100 percent feedback than for the group under 60 percent feedback. O'Connell replicated this result in a later study (O'Connell & Wagner, 1967).

Two studies report different findings. Sax (1960) studied the effect of providing feedback on 50 or 100 percent of trials to high school students categorizing Chinese ideographs, and found no significant differences between the two levels of feedback. Osler and Shapiro (1964) studied concept identification in children 6, 8, 10, and 14 years of age. Feedback was provided by giving the child a marble for a correct response. Two levels of feedback were given, "continuous" in which the child was given a marble after each correct response, and "partial" in which the child was given a marble after every second correct response. The percentage of trials with feedback did not affect the number of trials to criterion for 6-year-olds, but partial feedback increased the trials required for 8-, 10-, and 14-year-olds. With feedback trials to criterion as the dependent variable, 6-year-olds required <u>fewer</u> feedback trials under partial than under continuous feedback, while 14-year-olds required <u>more</u> feedback trials under partial than under continuous feedback. Subjects were also divided into high and average intelligence groups, and it was found that under continuous feedback, subjects of high intelligence were significantly superior to those of average intelligence; under partial feedback the two groups were equivalent.

As percentage of intermittent reinforcement of an irrelevant dimension increases, concept learning decreases. When feedback is given concerning the correctness of the subject's response with regard to the relevant dimensions, irrelevant dimensions will also be randomly reinforced. This reinforcement of the irrelevant dimensions would be expected to interfere with attainment of the concept.

Gormezano and Grant (1958) investigated performance on the Wisconsin Card Sorting Test when one of the irrelevant dimensions was reinforced 0, 25, 50, or 75 percent of the time. Total trials and correct responses increased as percentage of intermittent reinforcement of the irrelevant dimension increased (recall that an increase in these measures on the card sorting task indicates a decrease in performance). Number of errors, however, did not increase. This is probably due to the fact that there is less opportunity to make errors as intermittent reinforcement increases.

Bourne and Haygood (1960) obtained conflicting results. College students were required to identify a geometric concept based on one relevant dimension. One, three, or five irrelevant dimensions were introduced in order to vary task complexity, and one of these irrelevant dimensions was reinforced 50, 60, 70, 80, 90, or 100 percent of the time. As reinforcement increased from 50 to 100 percent, both the number of correct responses and the number of errors decreased. Thus, Gormezano and Grant (1958) found that performance decreased with increasing reinforcement, while Bourne and Haygood (1960) found that performance increased. One methodological difference between the experiments should be pointed out; Gormezano and Grant used a four-category sorting problem, Bourne and Haygood a two-category problem.

As Bourne and Haygood noted, increasing intermittent reinforcement exerts two opposing effects: (a) it makes the relevant and the intermittently reinforced dimensions more distinctive than the other irrelevant dimensions, which would tend to facilitate performance, and (b) it makes the final discrimination between the relevant and the intermittently reinforced dimensions more difficult, which would tend to hinder performance. Further studies may be required to determine which of these effects will predominate in a given situation.

Buss (1959) showed that intermittent reinforcement of a formerly relevant dimension impeded learning of a new concept. College students were required to sort blocks according to shape with 100 percent reinforcement. The basis of sorting was then changed to height, and the previously-learned shape discrimination received 0, 25, 50, or 75 percent reinforcement. The greater the percentage of reinforcement, the more the previously acquired concept was maintained. Gormezano and Abraham (1961a) performed essentially the same experiment as Buss, using the Wisconsin Card Sorting Test, and obtained the same results. Increasing intermittent reinforcement of the irrelevant dimension also increased difficulty of concept learning over repeated nonreversal shifts on a card sorting task (Gormezano & Abraham, 1961b).

In a nonreversal shift, one of the dimensions which was previously irrelevant becomes relevant. Increasing intermittent reinforcement of that dimension before the shift improves performance after the shift. Following the first stage of their experiment, Gormezano and Grant (1958) required their subjects to sort on the dimension which had previously been irrelevant and intermittently reinforced 0, 25, 50, or 75 percent of the time. Although no significant differences occurred, performance on all measures was better for the 75 percent group than for the 0 percent group.

Bourne and Haygood (1960) found significant performance differences during the second stage of a similar experiment. Subjects were given 50, 60, 70, 80, 90, or 100 percent reinforcement on an irrelevant dimension during the first stage of an experiment. They were then given a concept identification problem in which the previously intermittently reinforced dimension was relevant. Total errors increased from Stage 1 to Stage 2, but the number of errors in Stage 2 decreased as a function of increased intermittent reinforcement. For the 100 percent condition, positive transfer resulted.

Further evidence for the facilitative effect of increasing intermittent reinforcement prior to a nonreversal shift is found in an experiment by Guy, Van Fleet, and Bourne (1966). College students were required to learn a unidimensional geometric concept to a criterion of ten consecutive correct responses (Stage 1). Following criterion performance, a new dimension was added without interruption or instruction to the subject (Stage 2). This new dimension had a 50, 75, or 100 percent correlation with the initially relevant dimension. A nonreversal shift was then initiated, making the new dimension introduced during Stage 2 the relevant dimension (Stage 3). Mean trials to criterion in Stage 3 decreased as a linear function of rate of reinforcement for the added dimension during Stage 2.

Probability of Misinformative Feedback

Speed of concept learning decreases as the amount of misinformative feedback increases. Misinformative feedback produces a greater decrement in performance as task complexity increases. The effect of misinformation on concept learning may be studied by deliberately providing erroneous feedback on a specified percentage of trials. The subject is told that he is wrong when he has actually given a correct response; that he is correct when he has actually given a wrong response. Studies have shown without exception that the greater the percentage of misinformative feedback (MF), the greater the number of errors in concept identification (errors are scored with reference to the actual correctness or incorrectness of the subject's response, regardless of the feedback given).

Pishkin (1960) required college students to identify geometric concepts which were based on a single relevant dimension. Task complexity was varied by including 1, 3, or 5 irrelevant dimensions. Five degrees of MF were studied: 0, 10, 20, 30, and 40 percent. The results indicated a linear increase in mean number of errors as the percentage of MF increased. MF had a greater retarding influence as task complexity increased.

In a very similar experiment, Pishkin (1961) used psychiatric aides as subjects. He included one or three irrelevant dimensions, and 10 or 30 percent MF. The results were the same as those of the 1960 experiment.

Wolfgang, Pishkin, and Lundy (1962) used the same type of task as Pishkin, but MF was varied over only three degrees: 0, 15, and 30 percent. Subjects in this study were volunteer psychiatric aides who scored in the upper and lower 25 percent of the Christie and Budnitzky Forced Choice Anxiety Scale. It was predicted

that high anxious subjects would make significantly more errors than low anxious subjects as task complexity and amount of MF increased. As in Pishkin's 1960 study, increased MF decreased concept identification performance and the effect was greater as task complexity increased. No significant differences were found, however, between high and low anxious subjects.

Johannsen (1962) also used the same type of task, employed college students as subjects, and varied MF over four degrees: 0, 12.5, 25.0, and 37.5 percent. Again, increasing MF decreased concept identification performance, and there was a significant interaction between MF and task complexity. However, when the 0 percent MF (control group) was eliminated the interaction was no long significant.

Bourne (1963) utilized the same task with college students as subjects and only one level of task complexity, and also confirmed the detrimental effect of increasing MF (0, 10, 20, and 30 percent) on concept identification performance.

The limiting level of MF is 50 percent, in which case the feedback bears no relation to the correct solution. Pishkin (1965) used two levels of MF, 0 and 50 percent, and found that under 0 MF all subjects solved the problem by the 43rd trial, while under 50 MF none of the subjects had reached solution by the 50th trial, and were still responding at chance level.

Rhine and Silun (1958) in effect utilized MF in a study of attitude development. Prior to the experiment, a separate group of students rated traits (e.g., "lazy," "gifted") as desirable or undesirable. Traits which were rated with 90 percent agreement were used in the experiment itself. Subjects were asked to predict the traits attributed to a fictional group of people. Following the subject's prediction, the experimenter provided feedback. Since the purpose was to induce a negative concept attitude, all negative traits were called "characteristic" and all positive traits "not characteristic" in the 0 MF condition. Other groups were given 8, 20, 36, and 50 percent MF. The ability of the subjects to respond consistently in a manner reflecting a negative attitude decreased as the amount of MF was increased.

Related to the amount of MF is the distribution of MF over trials. At one extreme, MF may be distributed regularly (e.g., every 10th trial). At the other extreme, MF may be completely randomized over the total number of trials, in which case it would occur at irregular intervals. Intermediate between the two extremes would be MF which is randomized over a block of trials. Since several successive MF trials in a row may occur with irregularly distributed MF, one might predict that concept identification would be inhibited more in this case than with regularly distributed MF. This effect has been confirmed in an experiment by Pishkin (1961).

Misinformative feedback on one task inhibits performance on a later task with no misinformative feedback. When MF is introduced during a concept identification task, performance on a later task is affected. In general, concept identification with 0 MF is retarded by previous trials with MF. Johannsen (1962) gave subjects 200 trials which involved various degrees of MF. All subjects were then switched to 0 MF. When the effect of prior learning in terms of terminal performance under MF was partialed out, trials required to reach criterion under 0 MF increased as a function of the amount of MF administered during the early trials.

Rhine and Silun (1958) induced a negative concept attitude during the first phase of an experiment. This phase of the experiment involved varying degrees of MF. Subjects were then required to learn a positive concept attitude under conditions of 0 MF. Speed of learning during the second phase of the experiment was inversely related to the amount of MF employed in the first stage of the experiment.

Following 50 trials on a concept identification problem in which subjects were given 0 to 50 percent MF, Pishkin (1965) presented his subjects with a second problem. Feedback on the second problem was 100 percent accurate. Subjects who were exposed to 50 percent MF during the first phase produced significantly more errors during the second phase than those who had not been exposed to MF. Two alternative explanations were proposed by Pishkin to account for this result: (a) 50 percent MF subjects had a greater universe of hypotheses during the second phase since they were unable to validate any of their hypotheses during the first phase, and (b) failure during the first phase decreased the subjects' motivation.

Yet another interpretation of the effect of MF on subsequent performance is offered by Levine (1963). Data from previous experiments had indicated that random reinforcement trials (equivalent to 50 percent MF) depressed subsequent learning compared to control groups with no random reinforcement trials. Also, informal comments by subjects implied that hypotheses tried and rejected during random

reinforcement trials were not tested again. These considerations led Levine to conclude that rejected hypotheses had a lowered probability of being resampled.

Consistent response to the relevant dimension can be learned despite misinformative feedback. Under MF, a subject will not receive consistently positive feedback even though he has actually identified the concept. Faced with this situation, many subjects attempt to match their categorizing behavior to the feedback patterns. The result is that the percentage of errors committed is approximately equal to the percentage of MF—a phenomenon known as probability matching.

Both Pishkin (1960) and Johannsen (1962) found adequate matching between the percentage of MF and the average number of errors for levels of MF up to about 25 percent. Beyond this, the average number of errors was larger than predicted.

Bourne (1963) predicted that probability matching behavior was a transitory stage in performance which would disappear if a larger number of trials were given. Four percentages of MF were investigated: 0, 10, 20, and 30. Subjects were presented with a single problem for three successive days, with 200 trials per day. At the end of the three days, 0 and 10 percent MF subjects reached problem solution (consistent response to the relevant dimension), and the 20 and 30 percent MF subjects evidenced performance tending toward problem solution. On the fourth day, subjects were switched to a different problem and run for 200 trials a day with 15 percent MF for three additional days. On this second task all subjects, including those who had previously received 0 MF, reached problem solution. Thus it may be concluded that subjects can solve problems even though a relatively large proportion of feedback is misleading.

Motivational Effects of Feedback

Invalidation of hypotheses has aversive effects, leading to decreased hypothesis-offering behavior. Wallace (1964) theorized that informing a subject that his hypothesis concerning a concept is incorrect might inhibit further hypothesizing. He based this prediction on the outcome of verbal conditioning research which had shown definite behavior modification due to the responses of the experimenter. To test for inhibition as a result of verbal hypothesis invalidation, Wallace compared the ratio of total hypotheses to total instances required for solution for subjects in two conditions: (a) verbal feedback given by the experimenter, and (b) auditory feedback signal. Subjects given mild verbal feedback offered a lower ratio of hypotheses to total instances than did subjects given auditory feedback at a just-discriminable intensity level. Wallace interpreted this to mean that the verbal feedback aroused a "need for certainty" which caused the subject to delay giving a hypothesis until he was certain to be correct. Only one experimenter was involved in the conduct of the experiment, however, so experimenter effects were not controlled.

Further confirmation of the punishing effect of hypothesis invalidation was provided by Byers (1965). Like Wallace, Byers employed undergraduate psychology students as subjects, and confronted them with the task of solving conjunctive concepts utilizing geometric stimuli. Byers, however, used only one type of feedback, lights labelled "correct" or "wrong." It may be seen that if hypothesis invalidation served only as an additional source of information, no decrease in hypothesizing would be expected with practice. However, if invalidation had a mild aversive effect, we would predict that with practice (and, therefore, more invalidations) subjects would offer fewer hypotheses and those offered would occur with less unknown information. Both of the latter predictions were confirmed.

Both the Wallace and Byers experiments indicate that feedback may have aversive consequences as well as informational value. Further research is needed to compare the relative effects of various types of feedback as a function of practice. Possible interactions of this punishing effect with age and various personality characteristics should also be investigated.

Comments written by teachers on test papers improve performance on subsequent tests more than letter or numerical grades only. Comments written by teachers on homework or test papers may be considered as feedback. Although comments may contain an informational component, the primary function is to motivate the student by communicating the teacher's approval or disapproval of the student's overall performance. This type of feedback is molar compared with that usually given in concept learning experiments and would be expected to have a more generalized effect on behavior.

Page (1958) studied the effect of test paper comments by the teacher on students' subsequent test performance. Tests were graded, and students matched for performance were randomly assigned to one of three groups. The

"no comment" group received only a numerical and letter grade. The "specified comment" group received uniform comments designated beforehand for each letter grade. The "free comment" group received whatever comments the teacher thought appropriate. On the next objective test given in the class, the free comment and specified comment groups performed significantly better than the no comment group. Differences in performance between the free comment and specified comment groups, however, were not significant.

Sweet (1966) predicted that differences between the specified comment and free comment groups would develop if treatments were continued over a longer period of time. He therefore compared the performance of no comment, specified comment, and free comment groups on four tests given over a six-week period. Results indicated that the inclusion of free comments improved scholastic performance significantly, while specified comments had little or no effect. Attitudes toward the subject matter as measured by the three most factorially pure scales of Osgood's evaluative dimension were significantly changed in a positive direction by free comments.

Feedback which indicates reproof, or praise combined with reproof, for learning a particular concept results in a preference for that concept. Juzak (1955) presented college students with a series of problems which required them to learn geometric concepts based on a single relevant dimension. During the series of problems, subjects formed concepts of two kinds. Solution time for each problem was measured and feedback was given immediately following the problem. Feedback consisted of false norms concerning the subject's performance on the task. If the concept formed during the problem was to be reproved, a percentile rank indicating poor performance was indicated. If the concept was to be praised, a percentile rank indicating high performance was given. If it was to be neither praised nor reproved, average performance was indicated. In the learning series, one concept was given one type of feedback and the other concept was given a different kind of feedback. A test problem was then presented which, in actuality, could be solved by either of the two concepts which had been presented during the learning series. The concept chosen for solution was regarded as the subject's preference. Concepts learned with praise were not significantly preferred over concepts learned with nonpraise. Concepts learned with reproof, however, were significantly preferred over concepts learned with nonreproof. Preference for concepts learned with praise did not significantly differ from concepts learned with reproof. Juzak suggested that praise alone during learning did not arouse the need to achieve.

Subject Characteristics and Feedback

The effect of feedback variables may differ depending on characteristics of the subject such as age, ability, and socioeconomic background. Two studies which explored the interaction between feedback variables and subject characteristics have yielded significant results, suggesting that this would be a fruitful area for further investigation.

Zigler and deLabry (1962) compared tangible reinforcement (tokens to be exchanged for a toy) with intangible reinforcement (verbal feedback) on card-sorting performance. Three types of subjects were used: lower class, middle class, and retarded children. Results indicated that lower class and retarded children performed better on a concept learning task if they were given tangible rather than intangible reinforcement. With intangible reinforcement, middle class subjects did better than lower class or retarded subjects. Performance by the retarded and lower class groups under tangible reinforcement, however, equalled the performance of the middle class groups under tangible reinforcement.

A second study which examined interactions of feedback variables with age and intelligence was performed by Osler and Shapiro (1964) and was described in the section on probability of feedback. The evidence indicates that partial reinforcement is more detrimental to older or more intelligent subjects than to younger or less intelligent subjects.

Summary

Informative feedback is a crucial variable in concept attainment. Research indicates that feedback is most important after an incorrect response, and that it should be as complete as possible. In the case of an incorrect response, the subject should be informed which response would have been correct. He also may be given an explanation of the reason his response was correct or incorrect. If feasible, informative feedback should be provided on all trials. Finally, all feedback should be accurate.

V
Conclusion

In the preceding chapters, generalizations were drawn concerning the effects of instructions, temporal factors, and feedback. These generalizations are again listed here to permit ready reference.

Instructions

1. Instructions which explicitly indicate the dimensions on which concept instances vary may facilitate learning.

2. Intentional concept learning is generally more efficient than incidental concept learning.

3. Instructions which give a decision rule for utilizing the information in instances improve concept learning.

4. Under the selection paradigm, instruction in an appropriate strategy for selecting instances results in more rapid concept attainment.

5. Instructions which contain information concerning the relevant attributes or conceptual rule increase speed of concept learning. Knowledge of the relevant attributes is more facilitative than knowledge of the conceptual rule.

6. Subjects given instructions to attain concepts as quickly as possible learn concepts faster than subjects given instructions to attain the concepts with as few errors as possible. The two groups, however, do not differ in number of errors.

Temporal Factors

1. Increasing stimulus exposure time beyond a critical minimum facilitates concept learning.

2. A short, unfilled delay interval preceding feedback has little or no effect on concept attainment.

3. Improvement in concept learning performance occurs as the length of the postfeedback interval increases.

4. Intertrial intervals up to 60 seconds do not facilitate concept learning.

Informative Feedback

1. Performance in concept identification tasks is equivalent whether feedback is given after both correct and incorrect responses or after incorrect responses only. Performance is impaired, however, when feedback is given after correct responses only.

2. When feedback is given only after incorrect responses during acquisition, extinction is slower than when feedback is given after both correct and incorrect responses or correct responses only.

3. Under some conditions, increasing feedback completeness facilitates concept learning.

4. Increasing the number of trials with feedback improves performance on a

criterion series with no feedback. Performance on a subsequent task is also improved.

5. Performance on concept identification tasks is improved as the percentage of trials on which feedback occurs is increased.

6. As percentage of intermittent reinforcement of an irrelevant dimension increases, concept learning decreases.

7. In a nonreversal shift, one of the dimensions which was previously irrelevant becomes relevant. Increasing intermittent reinforcement of that dimension before the shift improves performance after the shift.

8. Speed of concept learning decreases as the amount of misinformative feedback increases. Misinformative feedback produces a greater decrement in performance as task complexity increases.

9. Misinformative feedback on one task inhibits performance on a later task with no misinformative feedback.

10. Consistent response to the relevant dimension can be learned despite misinformative feedback.

11. Invalidation of hypotheses has aversive effects, leading to decreased hypothesis-offering behavior.

12. Comments written by teachers on test papers improve performance on subsequent tests more than letter or numerical grades only.

13. Feedback which indicates reproof, or praise combined with reproof, for learning a particular concept results in a preference for that concept.

These generalizations indicate that certain kinds of instructions, temporal factors, and feedback variables have predictable effects. Further research should be carried out to determine the degree to which these same variables might prove effective in facilitating the learning of concepts in the classroom.

In addition, several of these generalizations have implications for a model of cognitive operations in concept learning. Klausmeier and Frayer (1970) proposed that strategies in concept attainment consist of three phases: attending to the situation, securing information, and processing and using information. Specific cognitive operations in each of the three phases were also identified (see Figures 1, 2, and 3 reprinted from Klausmeier & Frayer, 1970). The relationships between these specific cognitive operations and the generalizations drawn in this paper will be briefly described.

Klausmeier and Frayer postulated that cognizing the structure of the concept population was an important aspect of attending to the concept learning task. The research reviewed in this paper showed that instructions which explicitly indicate the dimensions on which concept instances vary may facilitate learning. This generalization supports the postulated

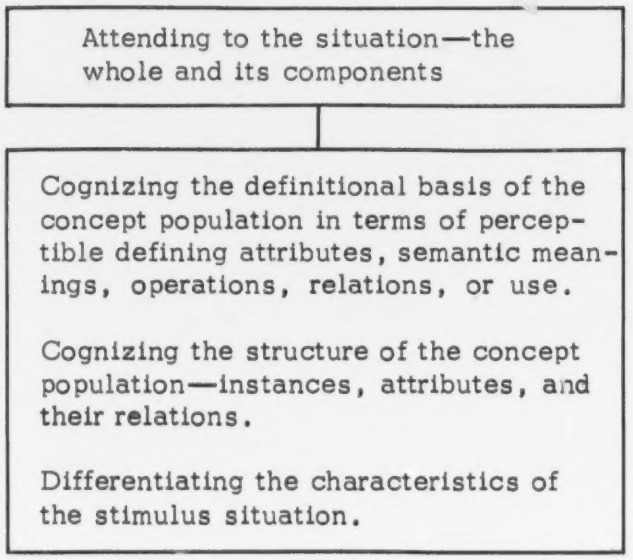
Attending to the situation—the whole and its components
Cognizing the definitional basis of the concept population in terms of perceptible defining attributes, semantic meanings, operations, relations, or use.
Cognizing the structure of the concept population—instances, attributes, and their relations.
Differentiating the characteristics of the stimulus situation.

Figure 1. Specific Operations Involved in Attending to the Situation

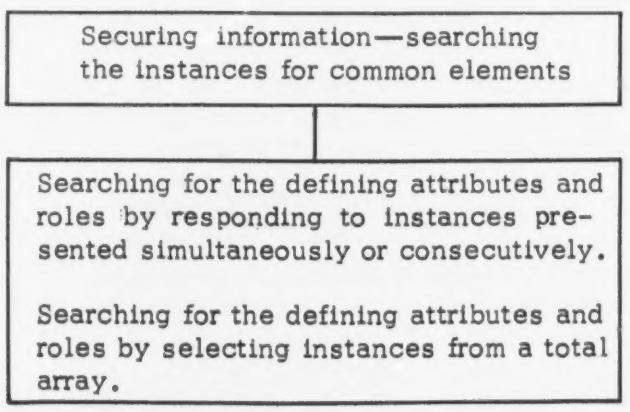
Securing information—searching the instances for common elements
Searching for the defining attributes and roles by responding to instances presented simultaneously or consecutively.
Searching for the defining attributes and roles by selecting instances from a total array.

Figure 2. Specific Operations Involved in Securing Information

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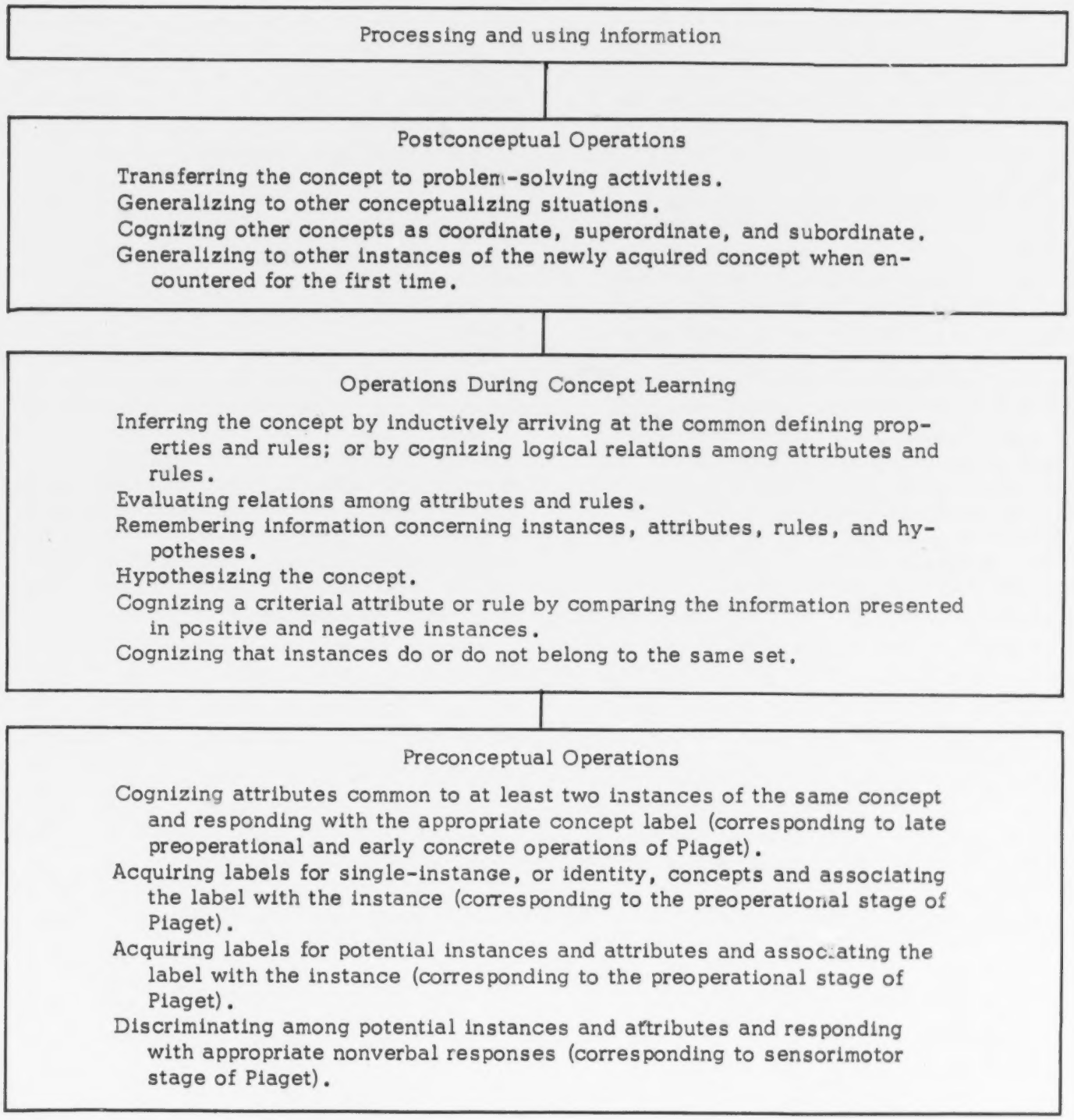
Processing and using information
Postconceptual Operations
Transferring the concept to problem-solving activities.
Generalizing to other conceptualizing situations.
Cognizing other concepts as coordinate, superordinate, and subordinate.
Generalizing to other instances of the newly acquired concept when encountered for the first time.
Operations During Concept Learning
Inferring the concept by inductively arriving at the common defining properties and rules; or by cognizing logical relations among attributes and rules.
Evaluating relations among attributes and rules.
Remembering information concerning instances, attributes, rules, and hypotheses.
Hypothesizing the concept.
Cognizing a criterial attribute or rule by comparing the information presented in positive and negative instances.
Cognizing that instances do or do not belong to the same set.
Preconceptual Operations
Cognizing attributes common to at least two instances of the same concept and responding with the appropriate concept label (corresponding to late preoperational and early concrete operations of Piaget).
Acquiring labels for single-instance, or identity, concepts and associating the label with the instance (corresponding to the preoperational stage of Piaget).
Acquiring labels for potential instances and attributes and associating the label with the instance (corresponding to the preoperational stage of Piaget).
Discriminating among potential instances and attributes and responding with appropriate nonverbal responses (corresponding to sensorimotor stage of Piaget).

Figure 3. Specific Operations Involved in Processing and Using Information

importance of cognizing the attributes of concept instances.

Another aspect of the concept learning task identified by Klausmeier and Frayer was that of securing information. The influence of this aspect of the task could be demonstrated by evidence that efficiency of securing information was related to concept attainment. Research has shown that under the selection paradigm, instruction in an appropriate strategy for selecting instances results in more rapid concept attainment. Thus, at least under the selection paradigm, the search for information plays an important role in learning.

Several of the generalizations concerning instructions and temporal factors relate to the processing of information obtained from instances. In this paper it was noted that an increase in stimulus exposure time facilitates concept attainment. This effect was attributed,

in part, to better retention of instances which corroborates the importance of remembering information concerning concept instances.

Hypothesizing the concept was another cognitive operation postulated by Klausmeier and Frayer to be entailed in concept learning. In this paper, it was shown that feedback after only incorrect responses is equivalent to feedback after both correct and incorrect responses in its effect on concept learning. Feedback after correct responses only, on the other hand, results in impaired performance. One interpretation of this generalization was that the unit of behavior affected by feedback is the subject's hypothesis, and that feedback after correct responses produces no change in the hypothesis. If this interpretation is accepted, this generalization would provide evidence for the occurrence of hypothesizing.

Another operation identified by Klausmeier and Frayer was cognizing a criterial attribute or rule by comparing the information presented in positive and negative instances. Two of the generalizations formulated in this paper provide evidence for the role of this operation in concept learning. First, instructions which give a decision rule for utilizing the information in instances have been shown to improve concept learning. Second, instructions which contain information concerning the relevant attributes or conceptual rule increase speed of concept learning. The importance of inferring the attributes and rule is shown by the fact that concept attainment is greatly improved by either providing rules to aid inference or directly providing the information.

Thus, the research summarized in this paper provides support for many aspects of the cognitive operations model proposed by Klausmeier and Frayer. The relationships between the task variables discussed in this paper and the cognitive operations entailed in concept learning have been touched on only briefly. It appears, however, that the generalizations concerning task variables may have implications for cognitive theory as well as educational practice.

References

Amster, H. The relation between intentional and incidental concept learning as a function of multiple stimulation and cognitive style. Journal of Personality and Social Psychology, 1965, 1, 217-223.

Amster, H. Effect of instructional set and variety of instances on children's learning. Journal of Educational Psychology, 1966, 57, 74-85.

Archer, E. J., Bourne, L. E., Jr., & Brown, F. G. Concept identification as a function of irrelevant information and instructions. Journal of Experimental Psychology, 1955, 49, 153-164.

Ausubel, D. P. The psychology of meaningful verbal learning. New York: Grune and Stratton, 1963.

Bourne, L. E., Jr. Effects of delay of informative feedback and task complexity on the identification of concepts. Journal of Experimental Psychology, 1957, 54, 201-207.

Bourne, L. E., Jr. Long-term effects of misinformative feedback upon concept identification. Journal of Experimental Psychology, 1963, 65, 139-147.

Bourne, L. E., Jr. Human conceptual behavior. Boston: Allyn and Bacon, 1966.

Bourne, L. E., Jr., & Bunderson, C. V. Effects of delay of informative feedback and length of postfeedback interval on concept identification. Journal of Experimental Psychology, 1963, 65, 1-5.

Bourne, L. E., Jr., Dodd, D. H., Guy, D. E., & Justesen, D. K. Response-contingent postfeedback intervals in concept identification. Technical Report No. 18. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1967.

Bourne, L. E., Jr., Goldstein, S., & Link, W. E. Concept learning as a function of previously presented information. Journal of Experimental Psychology, 1964, 67, 439-448.

Bourne, L. E., Jr., Guy, D. E., Dodd, D. H., & Justesen, D. R. Concept identification: The effects of varying length and informational components of the intertrial interval. Journal of Experimental Psychology, 1965, 69, 624-629.

Bourne, L. E., Jr., Guy, D. E., & Wadsworth, N. Verbal-reinforcement combinations and the relative frequency of informative feedback in a card-sorting task. Journal of Experimental Psychology, 1967, 73, 220-226.

Bourne, L. E., Jr., & Haygood, R. C. Effects of intermittent reinforcement of an irrelevant dimension and task complexity upon concept identification. Journal of Experimental Psychology, 1960, 60, 371-375.

Bourne, L. E., Jr., & Pendleton, R. B. Concept identification as a function of completeness and probability of informative feedback. Journal of Experimental Psychology, 1958, 56, 413-420.

Braley, L. S. Strategy selection and negative instances in concept learning. Journal of Educational Psychology, 1963, 54, 154-159.

Brown, F. G., & Archer, E. J. Concept identification as a function of task complexity and distribution of practice. Journal of Experimental Psychology, 1956, 52, 316-321.

Buss, A. H. A study of concept formation as a function of reinforcement and stimulus generalization. Journal of Experimental Psychology, 1950, 40, 494-503.

Buss, A. H. Supplementary report: Maintenance of a previously learned concept as a function of partial reinforcement. Journal of Experimental Psychology, 1959, 58, 414-415.

Buss, A. H., & Buss, E. H. The effect of verbal reinforcement combinations on conceptual learning. Journal of Experimental Psychology, 1956, 52, 283-287.

Byers, J. L. Hypothesis behavior in concept attainment. Journal of Educational Psychology, 1965, 56, 337-342.

Byers, J. L. Verbal and concept learning. Review of Educational Research, 1967, 37, 494-513.

Byers, J. L., Davidson, R. E., & Rohwer, W. D., Jr. The effects of strategy instructions and memory on concept attainment. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 831-837.

Carpenter, F. Conceptualization as a function of differential reinforcement. Science Education, 1954, 38, 284-294.

Della-Piana, G. M. Searching orientation and concept learning. Journal of Educational Psychology, 1957, 48, 245-253.

DiVesta, F. J., & Walls, R. T. Response selection as a function of instructions and motivation under nonreinforcement conditions. Journal of Experimental Psychology, 1967, 73, 365-373.

DiVesta, F. J., & Walls, R. T. Rule and attribute identification in children's attainment of disjunctive and conjunctive concepts. Journal of Experimental Psychology, 1969, 80, 498-504.

Dunham, J. L., & Bunderson, C. V. Effect of decision-rule instruction upon the relationship of cognitive abilities to performance in multiple-category concept problems. Journal of Educational Psychology, 1969, 60, 121-125.

Erlebacher, A., & Archer, E. J. Perseveration as a function of degree of learning and percentage of reinforcement in card sorting. Journal of Experimental Psychology, 1961, 62, 510-517.

Fang, M. C. S. The effect of incentive and complexity on performance of students from two social class backgrounds on a concept identification task. Technical Report No. 10. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1966.

Frase, L. T. Paragraph organization of written materials: The influence of conceptual clustering upon the level and organization of recall. Journal of Educational Psychology, 1969, 60, 394-401.

Fredrick, W. C., & Klausmeier, H. J. Instructions and labels in a concept attainment task. Psychological Reports, 1968, 23, 1339-1342.

Gagné, R. M. The conditions of learning. New York: Holt, Rinehart, and Winston, 1965.

Gormezano, I., & Abraham, F. D. Intermittent reinforcement of a formerly relevant dimension in concept formation. Psychological Reports, 1961, 8, 111-116. (a)

Gormezano, I., & Abraham, F. D. Intermittent reinforcement, nonreversal shifts, and neutralizing in concept formation. Journal of Experimental Psychology, 1961, 61, 1-6. (b)

Gormezano, I., & Grant, D. A. Progressive ambiguity in the attainment of concepts on the Wisconsin Card Sorting Test. Journal of Experimental Psychology, 1958, 55, 621-627.

Grant, D. A., & Berg, E. A. A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. Journal of Experimental Psychology, 1948, 38, 404-411.

Grant, D. A., & Cost, J. R. Continuities and discontinuities in conceptual behavior in a card sorting task. Journal of General Psychology, 1954, 50, 237-244.

Guy, D. E., Van Fleet, F. M., & Bourne, L. E., Jr. Effects of adding a stimulus dimension prior to a non-reversal shift. Journal of Experimental Psychology, 1966, 72, 161-168.

Haygood, R. C., & Bourne, L. E., Jr. Attribute and rule learning aspects of conceptual behavior. Psychological Review, 1965, 72, 175-195.

Haygood, R. C., & Devine, J. V. Effects of composition of the positive category on concept learning. Journal of Experimental Psychology, 1967, 74, 230-235.

Haygood, R. C., & Stevenson, M. Effects of number of irrelevant dimensions in nonconjunctive concept learning. Journal of Experimental Psychology, 1967, 74, 302-304.

Holstein, S. B., & Premack, D. On the different effects of random reinforcement and presolution reversal on human concept identification. Journal of Experimental Psychology, 1965, 70, 335-337.

Johannsen, W. J. Concept identification under misinformative and subsequent informative feedback conditions. Journal of Experimental Psychology, 1962, 64, 631-635.

Johnson, P. J., Fishkin, A., & Bourne, L. E., Jr. Effects of procedural variables upon reversal and interdimensional shift performance: II. Psychonomic Science, 1966, 4, 69-70.

Juzak, T. The effects of praise and reproof on the generalization of learned concepts. Journal of Psychology, 1955, 39, 329-340.

Kagan, J., Rosman, B., Day, D., Albert, J., & Phillips, W. Information processing in the child: Significance of analytic and reflective attitudes. Psychological Monographs, 1964, 78 (1, Whole No. 578).

Kalish, P. W. Concept attainment as a function of monetary incentives, competition

and instructions. Technical Report No. 8. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1966.

Kendler, T. S. Concept formation. Annual Review of Psychology, 1961, 12, 447-472.

Klausmeier, H. J., & Frayer, D. A. Cognitive operations in concept learning. Working Paper No. 36. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1970.

Klausmeier, H. J., & Meinke, D. L. Concept attainment as a function of instructions concerning the stimulus material, a strategy, and a principle for securing information. Journal of Educational Psychology, 1968, 59, 215-222.

Klausmeier, H. J., Robinson, P. E., Frayer, D. A., & DeVault, M. L. A supplement to Technical Report No. 82. Concept learning: A bibliography, January-June, 1969. Technical Report No. 120. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1970.

Klausmeier, H. J., Sterrett, B. E., Frayer, D. A., Lewis, S. B., Lee, V.W., & Bavry, J. L. Concept learning: A bibliography, 1950-1967. Technical Report No. 82. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1969.

Klausmeier, H. J., Sterrett, B. E., Robinson, P. E., Frayer, D. A., & Bavry, J. L. A supplement to Technical Report No. 82. Concept learning: A bibliography, 1968. Technical Report No. 107. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1969.

Laughlin, P. R. Speed versus minimum-choice instructions in concept attainment. Journal of Experimental Psychology, 1964, 67, 596.

Laughlin, P. R., Doherty, M. A., & Dunn, R. F. Intentional and incidental concept formation as a function of motivation, creativity, intelligence, and sex. Journal of Personality and Social Psychology, 1968, 8, 401-409.

Levine, M. The assumption concerning "wrongs" in Restle's model of strategies in cue learning. Psychological Review, 1963, 70, 559-561.

Levine, M., Leitenberg, H., & Richter, M. The blank trials law: The equivalence of positive reinforcement and nonreinforcement Psychological Review, 1964, 71, 94-103.

Looney, N. J., & Haygood, R. C. Effects of number of relevant dimensions in disjunctive concept learning. Journal of Experimental Psychology, 1968, 78, 169-171.

Lynch, D. O. Concept identification as a function of instructions, labels, sequence, concept type, and test item type. Technical Report No. 6. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1966.

Marks, M. R., & Ramond, C. K. A new technique for observing concept evocation. Journal of Experimental Psychology, 1951, 42, 424-429.

Meyer, W. J., & Seidman, S. B. Age differences in the effectiveness of different reinforcement combinations on the acquisition and extinction of a simple concept learning problem. Child Development, 1960, 31, 419-429.

Meyer, W. J., & Seidman, S. B. Relative effectiveness of different reinforcement combinations on concept learning of children at two developmental levels. Child Development, 1961, 32, 117-127.

Milgram, N. A., & Furth, H. G. Factors affecting conceptual control in normal and retarded children. Child Development, 1967, 38, 531-543.

Miller, G. W., & Davis, J. K. Retention and concept identification as functions of concept complexity, method of presentation, stimulus exposure time, and conditions of recall. Technical Report No. 54. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1968.

Namikas, G., & Harris, D. Concept identification as a function of relevance of training and intertask instructions. Psychonomic Science, 1968, 12, 365-366.

O'Connell, D. C. Concept learning and verbal control under partial reinforcement and subsequent reversal or nonreversal shifts. Journal of Experimental Psychology, 1965, 69, 144-151.

O'Connell, D. C., & Wagner, M. V. Extinction after partial reinforcement and minimal learning as a test of both verbal control and PRE in concept learning. Journal of Experimental Psychology, 1967, 73, 151-153.

Oseas, L., & Underwood, B. J. Studies of distributed practice: V. Learning and retention of concepts. Journal of Experimental Psychology, 1952, 43, 143-148.

Osler, S. F., & Shapiro, S. L. Studies in concept attainment: IV. The role of partial reinforcement as a function of age and intelligence. Child Development, 1964, 35, 623-633.

Osler, S. F., & Weiss, S. R. Studies in concept attainment: III. Effect of instructions at two levels of intelligence. Journal of Experimental Psychology, 1962, 63, 528-533.

Page, E. B. Teacher comments and student performance: A 74 classroom experiment in school motivation. Journal of Educational Psychology, 1958, 49, 173-181.

Pishkin, V. Effects of probability of misinformation and number of irrelevant dimensions upon concept identification. Journal of Experimental Psychology, 1960, 59, 371-378.

Pishkin, V. Transmission of information as a function of misinformation feedback distribution. Psychological Reports, 1961, 9, 255-263.

Pishkin, V. Dimension availability with antecedent success or failure in concept identification. Psychonomic Science, 1965, 2, 69-70.

Pishkin, V. Availability of feedback-corrected error instances in concept learning. Journal of Experimental Psychology, 1967, 73, 318-319.

Pishkin, V., & Wolfgang, A. Number and type of available instances in concept learning. Journal of Experimental Psychology, 1965, 69, 5-8.

Podell, H. A. Two processes of concept formation. Psychological Monographs, 1958, 72 (15, Whole No. 468).

Reed, H. B. Factors influencing the learning and retention of concepts: I. The influence of set. Journal of Experimental Psychology, 1946, 36, 71-87.

Remstad, R. C. Optimizing the response to a concept attainment test through sequential classroom experimentation. Technical Report No. 85. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1969.

Rhine, R. J., & Silun, B. A. Acquisition and change of concept attitude as a function of consistency of reinforcement. Journal of Experimental Psychology, 1958, 55, 524-529.

Richardson, J., & Bergum, B. O. Distributed practice and rote learning in concept formation. Journal of Experimental Psychology, 1954, 47, 442-446.

Rothkopf, E. Z. Learning from written instructive materials: An exploration of the control of inspection behavior by test-like events. American Educational Research Journal, 1966, 3, 241-249.

Roweton, W. E., & Davis, G. A. Effects of preresponse interval, postinformative feedback interval, and problem difficulty on the identification of concepts. Journal of Experimental Psychology, 1968, 78, 642-645.

Sax, G. Concept acquisition as a function of differing schedules and delays of reinforcement. Journal of Educational Psychology, 1960, 51, 32-36.

Sax, G. Concept formation. In R. L. Ebel (Ed.), Encyclopedia of educational research. Fourth edition. New York: Macmillan, 1969. Pp. 196-205.

Shaffer, L. H. Concept formation in an ordering task. British Journal of Psychology, 1961, 52, 361-369.

Siegel, P. S. Concept formation: Response-time conditions. Psychological Reports, 1964, 14, 435-442.

Sweet, R. C. Educational attainment and attitudes toward school as a function of feedback in the form of teachers' written comments. Technical Report No. 15. Madison: Wisconsin Research and Development Center for Cognitive Learning, The University of Wisconsin, 1966.

Tagatz, G. E. The effects of selected variables upon information processing and information utilization in concept attainment tasks. Unpublished doctoral dissertation, University of Wisconsin, 1963.

Tagatz, G. E. Effects of strategy, sex, and age on conceptual behavior of elementary school children. Journal of Educational Psychology, 1967, 58, 103-109.

Tagatz, G. E., Walsh, M. R., & Layman, J. A. Learning set and strategy interaction in concept learning. Journal of Educational Psychology, 1969, 60, 488-493.

Ter Keurst, A. J. Effectiveness of explanatory reinforcement in programed learning of psychological concepts. Psychological Reports, 1964, 14, 489-490.

Ter Keurst, A. J. The intrinsic programmed approach to the discovery of concepts in general psychology. Journal of Experimental Education, 1965, 33. 351-355.

Underwood, B. J. Studies of distributed practice: XV: Verbal concept learning as a function of intralist interference. Journal of Experimental Psychology, 1957, 54, 33-40.

Underwood, B. J. Ten years of massed practice on distributed practice. Psychological Review, 1961, 68, 229-247.

Underwood, B. J. Some relationships between concept learning and verbal learning. In H. J. Klausmeier and C. W. Harris (Eds.), Analyses of concept learning. New York: Academic Press, 1966. Pp. 51-63.

Underwood, B. J., & Richardson, J. Verbal concept learning as a function of instruc-

tions and dominance level. Journal of Experimental Psychology, 1956, 51, 229-238.
Wallace, J. Concept dominance, type of feedback, and intensity of feedback as related to concept attainment. Journal of Educational Psychology, 1964, 55, 159-166.
Wells, H., & Watson, D. Strategy training and practice in disjunctive concept attainment. Psychological Reports, 1965, 17, 925-926.
Wittrock, M. C., & Twelker, P.A. Prompting and feedback in the learning, retention, and transfer of concepts. British Journal of Educational Psychology, 1964, 34, 10-18.
Wolfgang, A., Pishkin, V., & Lundy, R. M. Anxiety and misinformation feedback in concept identification. Perceptual and Motor Skills, 1962, 14, 135-143.
Zigler, E., & deLabry, J. Concept-switching in middle-class, lower-class, and retarded children. Journal of Abnormal and Social Psychology, 1962, 65, 267-273.

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